United States Environmental Protection Agency
Region 2

REVISED DRAFT – MANAGEMENT REVIEW COPY

NATIONAL REMEDY REVIEW BOARD BRIEFING PACKAGE AND CONTAMINATED SEDIMENT TECHNICAL ADVISORY GROUP CONSIDERATION MEMORANDUM

LOWER PASSAIC RIVER RESTORATION PROJECT

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LOWER PASSAIC RIVER RESTORATION PROJECT
REVISED DRAFT NRRB BRIEFING PACKAGE AND
CSTAG CONSIDERATION MEMORANDUM

TABLE OF CONTENTS

LIST OF FIGURES

All Figures are located in the "Figures" section following the document text.

LIST OF TABLES

Tables identified as "(attached)" are located in the "Tables" section following the document text. Other tables are contained within the document text.

LIST OF APPENDICES

1.0 NRRB BRIEFING PACKAGE SUMMARY

1.1 SITE SUMMARY

1.1.1 Site Name and Location

The Lower Passaic River Restoration Project ("the Study") is a comprehensive study of the 17-mile tidal portion of the Passaic River and its approximately 118 square-mile watershed (hereinafter referred to as the Study Area) in northern New Jersey. The 17-mile tidal portion of the Lower Passaic River is an operable unit of the Diamond Alkali Superfund Site in Newark, New Jersey. During the course of the Study, sediments in the lower eight miles of the river were identified as a major source of contamination to the 17-mile Study Area and to Newark Bay. Through a risk assessment and Focused Feasibility Study (FFS; Malcolm Pirnie, Inc., 2007b) conducted to comparatively analyze remedial alternatives, a Source Control Early Action is being evaluated to address these contaminated sediments in the lower eight miles of the Passaic River (hereinafter referred to as the Area of Focus). The Source Control Early Action, which will be a final action for the sediments in the lower eight miles, is intended to take place in the near term, while the comprehensive 17-mile Study is on-going.

1.1.2 Superfund Site Identification Number

The Superfund Site Identification Number for the Diamond Alkali Superfund Site is NJD980528996.

1.1.3 Operational History and Contaminants Present

The Lower Passaic River has a long history of industrialization. During the 1800s, the Lower Passaic River watershed was one of the major centers of the American industrial revolution, with early manufacturing, particularly cotton mills, developing in the area around Great Falls in Paterson. In subsequent years, many industrial operations developed along the banks of the Passaic River, including manufactured gas plants, paper manufacturing and recycling facilities, chemical manufacturing facilities, and others that used the river for wastewater disposal. Direct and indirect discharges from various facilities have resulted in poor water quality, contaminated sediments, bans on fish and shellfish consumption, lost wetlands, and degraded habitat. Furthermore, the Lower Passaic River has received direct and indirect municipal discharges from the middle of the nineteenth century to the present time. Together, these waste streams (industrial and municipal) discharged many contaminants, including dioxins, petroleum hydrocarbons, polychlorinated biphenyls (PCB), pesticides, and metals to the Lower Passaic River, all of which adsorb to fine-grained sediments and bioaccumulate into fish and shellfish.

The Superfund program history of the site started with the listing of the Diamond Alkali Superfund Site to the National Priority List (NPL) in 1984. At the time, the site was the 80-120 Lister Avenue facility in Newark, New Jersey, and the main contaminant of concern was 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-TCDD). In 1994, the six-mile stretch of the Passaic River in front of 80-120 Lister Avenue was designated another Operable Unit of the Diamond Alkali Superfund Site. In 2003, the six-mile stretch Remedial Investigation/Feasibility Study (RI/FS) was stopped, and the study was expanded to the 17-mile stretch of the Passaic River (also known as the Lower Passaic River), with an expanded list of contaminants including dioxins, PCBs, pesticides, polycyclic aromatic hydrocarbons (PAHs) and metals. In 2004, Newark Bay was designated yet another Operable Unit of the Diamond Alkali Superfund Site, with its own RI/FS on-going.

1.1.4 Key Features of the Site and the Surrounding Area

An important component of the region's historical development and urbanization was the deepening of the river to permit commercial navigation into the city of Newark and farther upriver. Several large dredging projects at the beginning of the twentieth century established and maintained a navigation channel through more than 15 miles of the river north of Newark Bay. Since the 1940s, there has been little maintenance dredging above river mile (RM) 2 and none since the early 1980s. Consequently, extensive fine grained sediment deposits exist in the channel, particularly between RM0 and RM8. The coincidence of contaminant discharges to the river and a significant suspended sediment load created an ideal situation for accumulating contaminated sediments. As a result, the river accumulated substantial sediment beds, measuring up to 25 feet thick in some areas. These thick sediment deposits remain, primarily below RM8 where the relatively wider river channel provided favorable conditions for rapid sediment accumulation. Relatively little accumulation has occurred upstream of RM8 because of the narrower channel conditions. Tidal mixing has distributed sediment contamination throughout the lower eight miles, as well as upriver and into Newark Bay and the New York – New Jersey Harbor Estuary.

Sediment contaminant concentrations are even greater in deeper sediments than at the surface. The combination of the navigational dredging activities and the long and extensive history of contaminant discharges to the Lower Passaic River have served to create a uniquely large inventory of highly contaminated sediments contained within a relatively small area. Other major Superfund sites may have similar volumes of contaminated sediments [*e.g.*, Hudson River PCB site at 2.6 million cubic yards (cy) (USEPA, 2002c) and Fox River PCB site at 8 million cy (USEPA, 2003b)], but these inventories are spread over much greater distances than the eight miles of the Lower Passaic River. While data are not sufficient to assess the volume of contaminated sediment for the entire Lower Passaic River, the volume is estimated at 5 to 8 million cy for RM0.9 to RM7.

Sediment erosion due to the back-and-forth motion of the tides and storm events is most likely responsible for continuing releases of contaminants from the river bed. As a fraction of all of the solids sources to the Lower Passaic, resuspension of deeper sediments comprises about 10 percent of the total annual deposition. However, resuspension accounts for over 95 percent of the dioxin accumulating in the river bottom, and at least 40 percent of PCBs, pesticides, and mercury accumulating in the river. Resuspension of legacy sediment accounts for 10 to 15 percent of the PAH contaminant burden and approximately 20 percent of the lead contaminant burden in the Lower Passaic River.

The Lower Passaic River is also a major source of contaminants to Newark Bay. Sediment transport from the Lower Passaic River to Newark Bay may be a significant source of the contaminants found in Newark Bay's surficial sediments, particularly dioxin. It is estimated that the Lower Passaic River contributes approximately 10 percent of the average annual amount of sediment accumulating in Newark Bay, and more than 80 percent of the dioxin accumulating in the Bay. A recent study of dioxin contamination in New York Harbor (Chaky, 2003) provides a basis for tracing the Lower Passaic River dioxin signature through the entire Harbor. It is estimated that the Lower Passaic River also contributes approximately 20 percent of the mercury to Newark Bay. (Mass balances on the amount of PCBs, PAHs, pesticides, and metals entering Newark Bay from the Lower Passaic River were not performed.)

Sediment contamination is not the only problem in the Lower Passaic River. Because of development along the banks of the Lower Passaic, vital wetlands and floodplains have been eliminated so that many of the communities living on the banks of the river are prone to flooding. The impacts of potential remedial actions on flooding and wetland restoration have been considered. Further, the State of New Jersey's vision for future navigation infrastructure has been considered to help define the reasonably anticipated future use for the Passaic River (see Section 2.5.2.3 "Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses").

1.1.5 On-Site and Surrounding Land Use

In general, the banks of the Lower Passaic River are highly developed with a combination of industrial, recreational, and residential land uses (see Section 2.5.1.1 "Current On-Site Land Use" for further information). The left bank (ascending) of the river between RM0.0 and RM4.6 (Newark, New Jersey) is fully industrially developed, and the right bank (ascending) in this region (Harrison, New Jersey) is occupied by the railroad tracks of the Port Authority Trans Hudson (PATH) system and an intermodal container handling facility. Upriver of RM4.6, the left bank is dominated by McCarter Highway (New Jersey Route 21), which extends along the left bank, northward to Dundee Dam. The right bank in the area of RM4.6 is currently being redeveloped for a combination of residential and recreational uses. Continuing upriver to Dundee Dam, the right bank can be characterized as recreational parkland containing small public marinas and private docking facilities. Residential and light commercial areas are also present along the banks of the river. Current land use in the surrounding counties in New Jersey (*i.e.*, Bergen, Hudson, Essex, and Passaic Counties) consists of a combination of industrial, residential, and commercial uses.

1.1.6 Media and Primary Contaminants of Concern

The remedial alternatives developed in the FFS address contamination in the fine-grained sediments in the Area of Focus (lower eight miles). Contaminants of potential concern (COPCs) and contaminants of potential ecological concern (COPECs) as identified for the FFS (Malcolm Pirnie, Inc., 2007b) are listed in Table 1.1-1.

Table 1.1-1: COPCs and COPECs in the Sediments of the Lower Passaic River

Analyte	Human Health COPC	Ecological COPEC
Inorganic Compounds		
Copper		✓
Lead		✓
Mercury	✓	✓
Semivolatile Organic Compounds (PAHs)		
Low Molecular Weight (LMW) PAH [1]		✓
High Molecular Weight (HMW) PAH [2]		✓
PCBs		
Total PCBs (sum of Aroclors)	✓	✓
Pesticides/Herbicides		
Chlordane	✓	
Dieldrin	✓	✓
Dichlorodiphenyldichloroethane (DDD) [3]	✓	
Dichlorodiphenyldichloroethylene (DDE) [3]	✓	
Dichlorodiphenyltrichloroethane (DDT) [3]	✓	
Total DDT [3]		✓
Polychlorinated dibenzodioxins/furans (PCDD/F)		
(2,3,7,8-TCDD	✓	✓
Tetrachlorodibenzidioxin (TCDD) Toxic Equivalent Quotient (TEQ) for PCDD/F	✓	✓
TCDD TEQ for PCBs	✓	✓

[1] LMW PAH is defined as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene. Samples flagged as not detected are incorporated into the summation as zero.
[2] HMW PAH is defined as the sum of benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, indeno[1,2,3-c,d]pyrene, and pyrene. Samples flagged as not detected are incorporated into the summation as zero. Total PAH is the sum of HMW PAH and LMW PAH.
[3] DDD, DDE, and DDT refers only to the 4,4'-isomers. Total DDT is defined as the sum of DDD, DDE, and DDT.

1.1.7 Operable Units and the Media Addressed by Each Operable Unit

The 17-mile stretch of the Lower Passaic River is an Operable Unit (OU) of the Diamond Alkali Superfund Site. The Source Control Early Action remedial alternatives address the entire Area of Focus, defined as the contaminated fine-grained sediments in the lower eight miles of the Passaic River, which is a portion of the OU.

1.2 RISK SUMMARY

Extremely contaminated surface sediments present risks to human heath and the ecosystem that exceed the ranges identified in the National Contingency Plan (NCP; USEPA, 1990). A Human Health Risk Assessment (HHRA) (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) conducted to support the FFS was developed consistent with the United States Environmental Protection Agency's (USEPA) risk assessment guidance, policies and guidelines. This focused risk analysis concentrated on the main risk pathway of ingestion of fish and crab, and a full baseline HHRA for all chemicals, receptors, and exposure pathways will be conducted in the future for the entire 17-mile site to refine the conservative analyses conducted for the FFS.

The risk assessment evaluated risks from the bioaccumulative COPCs including PCBs, dioxins, DDD, DDE, DDT, dieldrin, chlordane, and methyl mercury. The toxic equivalent factors (TEFs; Van den Berg *et al*., 1998 and Van den Berg *et al*., 2006) for dioxin and dioxin-like PCBs were used in the analysis. The HHRA concluded that risks to adults exposed for 24 years and children exposed for 6 years are 1×10^{-2} and 2×10^{-2}, respectively, for ingestion of fish and crab. The adults were assumed to consume 40 eight-ounce fish meals per year [25 grams per day from the Exposure Factors Handbook (EFH; USEPA, 1997)], and the ingestion rate for children was adjusted based on body weight. The non-cancer health hazards for fish consumption are 64 for adults and 99 for children; the non-cancer health hazards for crab consumption are 86 for adults and 140 for children. A separate analysis for adolescents was also conducted. The associated cancer risks are 2×10^{-3} for ingestion of fish and 4×10^{-3} for ingestion of crab; the associated non-cancer health hazards are 55 for ingestion of fish and 72 for ingestion of crab.

The risks to the reasonable maximum exposure (RME) and to the central tendency exposure (CTE) individuals (described in Section 2.6.1 "Human Health Risk Assessment Summary") are greater than the risk range established in the Superfund Program of one in ten thousand to one in a million. Approximately 65 percent of the human health cancer risk is associated with the presence of dioxin. Most of the remaining cancer risk (approximately 33 percent) is from PCBs, while pesticides and mercury combined contribute approximately two percent. Total PCBs are the primary contributor to the excess non-cancer hazard for all receptors for ingestion of both fish and crab. Accordingly, fish consumption advisories have been in place for many years due to contamination from dioxins and PCB.

The Ecological Risk Assessment (ERA) (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) conducted to support the FFS was developed consistent with the USEPA's risk assessment guidance, policies, and guidelines. Direct contact exposures by sediment-associated receptors and indirect exposures (*i.e.*, bioaccumulation through the food web) to contaminated sediment were evaluated in the ERA. The indirect exposures evaluated bioaccumulation hazards to aquatic organisms that forage in the Lower Passaic River and the wildlife that consume these organisms. Receptors of interest included benthic macroinvertebrates, crab, fish (forage and predatory), mammals (mink), and birds (great blue heron).

A chemical screening process resulted in the selection of nine COPECs, including copper, lead, mercury, LMW PAH, HMW PAH, dieldrin, Total DDT, Total PCBs, and TCDD TEQ, including contributions from PCDD/F and PCB congeners. The ERA concluded that ecological receptors residing in the river are being adversely impacted. The total hazard indices (HIs) estimated for the benthic macroinvertebrates range from 540 to 5,100. For the fish, HIs are estimated between 220 and 27,000. HIs to mammals and birds range from 72 to 1600 and 16 to 150, respectively.

The estimated hazards to the ecological receptors (described in Section 2.6.2 "Ecological Risk Assessment Summary") are greater, by two to four orders of magnitude, than 1.0.

In general, an HI above 1.0 indicates the potential for significant risk; an HI below 1.0 indicates a low potential for risk. COPECs contributing to an HI above 1.0 vary with each of the receptors. In general, the primary contributors for the benthic invertebrates are dieldrin, Total DDT, and TCDD TEQ for PCDD/F. For the forage fish, copper was the primary contributor, with a slight contribution from Total PCBs. Copper and Total DDT accounted for the majority of the HI for the predatory fish. Total TCDD TEQ accounted for the majority of the HI for both modeled wildlife receptors; however, the relative contribution of PCDD/F and PCB compounds to the HI differed substantially. For the mink, PCDD/F compounds accounted for well over 50 percent of the TEQ, whereas for the great blue heron, PCB compounds made the most substantial contribution to the TEQ.

1.3 REMEDIATION GOALS

Remedial Action Objectives (RAOs) were established to describe what the cleanup is expected to accomplish, and preliminary remediation goals (PRGs) were developed as targets for the cleanup to meet in order to protect human health and the environment.

The RAOs were developed by the USEPA with input from the partner agencies[1] regarding current and reasonably anticipated future uses of the site. The RAOs are as follows:

[1] The Lower Passaic River Restoration Project is being implemented by the USEPA under the Superfund Program; by the United States Army Corps of Engineers (USACE) and New Jersey Department of Transportation (NJDOT) under the Water Resources Development Act (WRDA); and by the United States Fish and Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA), and the New Jersey Department of Environmental Protection (NJDEP) as Natural Resource Trustees.

- Reduce cancer risks and non-cancer health hazards for people eating fish and shellfish from the Lower Passaic River by reducing the concentration of COPCs in fish and shellfish.

- Reduce the risks to ecological receptors by reducing the concentration of COPECs in fish, shellfish, and benthic organisms.

- Reduce the mass of COPCs and COPECs in sediments that are or may become bioavailable.

- Remediate the most significant mass of contaminated sediments that may be mobile (*e.g.*, erosional or unstable sediments) to prevent it from acting as a source of contaminants to the Lower Passaic River or to Newark Bay and the New York-New Jersey Harbor Estuary.

Applicable or relevant and appropriate requirements (ARARs), human health and ecological risk-based concentrations (RBCs), and background concentrations were evaluated in the selection of PRGs. The background concentrations derived from recent sediment data from above Dundee Dam were found to be above the risk-based thresholds. Since the Superfund program, generally, does not clean up to concentrations below natural or anthropogenic background levels (USEPA, 2002d), background concentrations from sediment above Dundee Dam were selected as PRGs. Table 1.3-1 lists the background concentrations of COPECs and COPCs, selected as the PRGs.

Table 1.3-1: Selected PRGs

Contaminant	Background Concentration (ng/g)
Copper	80,000
Lead	140,000
Mercury [1]	720
LMW PAH	8,900
HMW PAH	65,000

Contaminant	Background Concentration (ng/g)
Total PCB	660
Sum of DDD, DDE, and DDT isomers (Total DDx)	91
Dieldrin	4.3
Chlordane	92
2,3,7,8-TCDD	0.002

[1] All occurrences of mercury are assumed to be methylated for purposes of this evaluation.

The proposed remediation goals assume that institutional controls will be in place that will require that the current fish advisories in the Lower Passaic River be evaluated on an ongoing basis. It is anticipated that these advisories can be relaxed as contaminant concentrations continue to decline after implementation of the Source Control Early Action.

The COPC and COPEC concentrations known to exist in the surface sediments of the lower 8 miles are much greater than these PRGs. For this reason a remedial strategy that can reduce the concentrations to at least the level of background is necessary to begin to achieve the RAOs.

The background levels for many of the contaminants pose unacceptable risks, in part resulting from continuing contributions from upstream sources. Thus, while the Source Control Early Action addresses the contaminated sediments of the lower eight miles of the Passaic River, a separate source control action will need to be implemented above Dundee Dam to identify and reduce or eliminate those background sources.

1.4 DESCRIPTION OF REMEDIAL ALTERNATIVES

A description of the No Action and six active remedial alternatives for the Lower Passaic River Restoration Project is presented in Table 1.4-1. The remedial alternatives and cost estimates were developed as part of the FFS (Malcolm Pirnie, Inc., 2007b).

The six active remedial alternatives are equivalent in risk reduction and the estimated time to achieve preliminary remediation goals. Based on the prediction of future surface sediment concentrations generated in the Empirical Mass Balance Model (EMBM) (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b), active remediation of the Area of Focus followed by monitored natural recovery (MNR) will achieve any PRG for 2,3,7,8-TCDD, which is responsible for about 65 percent of the risk, 40 years faster than it would be achieved by MNR alone. The reduction of other COPCs and COPECs is also accelerated by active remediation of the Area of Focus.

Table 1.4-1: Description of Active Remedial Alternatives

Alternative	Navigation Usage and Navigation Channel Depths [1]	Flooding [2] (additional flooding)	Dredging Volume (millions of cubic yards)	Construction Time	Human Health Risk Assessment [3] (Fish Consumption) [4]	Ecological Risk Assessment [3] (Heron) [5]	DMM Scenario	Total Present Worth Costs
No Action	Similar to Current Use Alternative 4; limits feasibility of future channel maintenance	Gradual Increase with time (not estimated)	0	Not applicable	Cancer Risk: 1×10^{-2} Non-Cancer HI: 64 for adult receptor; 99 for child receptor	Cancer Risk: 2×10^{-2} Non-Cancer HI: 49	Not applicable	Not applicable
Alternative 1: Removal of Fine-Grained Sediment from Area of Focus	Authorized channel dimensions accommodated (see Alternative 3 below)	Decrease (not estimated)	11.0	12 years	Cancer Risk: 5×10^{-4} (95 percent reduction compared to baseline) Non-Cancer HI: 4.7 for adult receptor; 22 for child receptor	Cancer Risk: 4×10^{-4} (98 percent reduction compared to baseline) Non-Cancer HI: 1.8	A [6]	$1,947,000,000
							B [7]	$2,272,000,000
Alternative 2: Engineered Capping of Area of Focus	Navigation significantly reduced	Considerable Increase (93 acres)	1.1	6 years			A	$863,000,000
							B	$1,111,000,000
Alternative 3: Engineered Capping of Area of Focus Following Remediation of Federally Authorized Navigation Channel	Authorized channel dimensions accommodated • 30 feet from RM0 to RM2.5 • 20 feet from RM2.5 to RM4.6 • 16 feet from RM4.6 to RM8.1 • 10 feet above RM8.1	Decrease (not estimated)	7.0	8 years			A	$1,518,000,000
							B	$1,845,000,000
Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage	Current navigation usage accommodated • 30 feet from RM0 to RM1.2 • 16 feet from RM1.2 to RM2.5 • Navigation above RM2.5 significantly reduced	Considerable Increase (24 acres)	4.4	6 years			A	$1,267,000,000
							B	$1,596,000,000
Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage	Anticipated future navigation usage accommodated • 30 feet from RM0 to RM1.2 • 16 feet from RM1.2 to RM3.6 • 10 feet above RM3.6	Decrease (-17 acres)	6.1	7 years			A	$1,421,000,000
							B	$1,749,000,000
Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine-Grained Sediment from Primary Inventory Zone and Primary Erosional Zone		Decrease (not estimated)	7.0	8 years			A	$1,496,000,000
							B	$1,824,000,000

DMM: Dredged Material Management

[1] Navigation channel depths are provided in feet below mean low water.

[2] Flood estimates are provided for the 100-year return interval river flow event.

[3] Risk reductions presented are for a 30-year timeframe. Alternatives 1 though 6 rely on MNR with institutional controls in place to achieve 1×10^{-4} and HI = 1 in subsequent years. In addition, separate source control actions above Dundee Dam, when implemented, will accelerate the time frame to reach 1×10^{-4} and HI = 1. Quantitative estimates of risk reduction are subject to the uncertainties in the EMBM and Risk Assessment, as described in Section 3.6 "Carefully Evaluate the Assumptions and Uncertainties Associated with Site Characterization Data and Site Models." However, inferences inherent in these evaluations have been derived from a thorough and comprehensive understanding of the site through the Conceptual Site Model (CSM), which was built upon detailed geochemical data evaluations and the assimilation of various data sources.

[4] A HHRA was also conducted for the scenario of crab consumption. Refer to the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) for additional information.

[5] An ERA was also conducted for other species. Refer to the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) for additional information.

[6] DMM Scenario A: Nearshore Confined Disposal (see Section 2.8 "Description of Remedial Alternatives")

[7] DMM Scenario B: Nearshore Confined Disposal, Storage, Thermal Treatment, and Beneficial Use of the Treated Material (see Section 2.8 "Description of Remedial Alternatives")

1.5 STAKEHOLDER VIEWS

1.5.1 State's Position

State acceptance is not addressed in this document, but will be addressed in the Record of Decision (ROD). It is important to note that the NJDOT is the WRDA non-federal sponsor and the NJDEP is a Trustee for the site; both are agency partners participating in the Study. As such, input from the State of New Jersey was sought and considered throughout the development of the FFS. In addition, the NJDOT developed a memorandum outlining the State's recommendations for the depth of the navigation channel to accommodate future use; this memorandum guided the development of several remedial alternatives for the Lower Passaic River.

1.5.2 Major Stakeholders' Position

Community acceptance of the Source Control Early Action will be assessed in the ROD once public comments on the proposed plan have been reviewed and taken into account. Input from the public and interested stakeholders, including the partner agencies, was sought and considered throughout the development of the FFS. This occurred through various technical workgroup sessions organized and hosted by the USEPA, through publication of information on the project website (www.ourPassaic.org), publication of information to interested members of the public in the form of ListServ notices, and other community involvement activities. A municipalities workshop was held in April 2007 to share project information and address community-specific concerns. Municipalities that participated in the workshop include Bayonne, Bloomfield, Clifton, Elizabeth, Garfield, Harrison, Newark, Nutley, and Rutherford. Another meeting was held in July 2007 to brief the municipalities of the lower eight miles on the Source Control Early Action FFS. The towns of Kearny and Harrison, the City of Newark, and Hudson County participated in this meeting.

2.0 NRRB BRIEFING PACKAGE

2.1 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

The Lower Passaic River Restoration Project ("the Study") is a comprehensive study of the 17-mile tidal portion of the Passaic River and its watershed in northern New Jersey. This integrated Study is being implemented by the USEPA under the Superfund Program (the Lower Passaic River is a part of the Diamond Alkali Superfund Site); by the USACE and NJDOT under WRDA; and by the USFWS, NOAA, and the NJDEP as Natural Resource Trustees. The scope of the Study is to gather data needed to make decisions on remediating contamination in the river to reduce human health and ecological risks, improve the water quality of the river, improve and create aquatic habitat, improve human use, and reduce contaminant loading in the Lower Passaic River, Newark Bay, and the New York-New Jersey Harbor Estuary.

The Study Area (118 square miles) is defined as the Lower Passaic River and its basin, which comprises the tidally-influenced portion of the river from the Dundee Dam (RM17) to Newark Bay (RM0), and the watershed of this river portion downstream of the dam, including tributaries such as the Saddle River, Second River, and Third River (Figure 2.1-1).[2]

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[2] Note that two systems exist for identifying locations in the Lower Passaic River (Figure 2.1-2). The system used in this document to identify locations along the river is based on the centerline of the USACE navigation channel. However, data evaluations for the Lower Passaic River use a slightly (about ¼ mile) different river mile system, which is referred to in this document as the "RI/FS system." The RI/FS system uses a centerline that is equidistant from each shore and independent of the federally authorized navigation channel. River mile locations in this document are provided using the USACE system, except where noted.

During the course of the Study, sediments in the lower eight miles of the river were identified as a major source of contamination to the 17-mile Study Area and to Newark Bay. An FFS (Malcolm Pirnie, Inc., 2007b) was undertaken to evaluate a range of remedial alternatives that might be implemented as an early action to control that major source. The Source Control Early Action will address contaminated sediments in the lower eight miles of the Passaic River (hereinafter referred to as the Area of Focus; Figure 2.1-2), in order to more rapidly reduce risks to human health and the environment. The Source Control Early Action, which will be a final action for the sediments in the lower eight miles, is intended to take place in the near term, while the comprehensive 17-mile Study is ongoing.

2.2 SITE HISTORY AND ENFORCEMENT ACTIVITIES

The Lower Passaic River has a long history of industrialization. During the 1800s, the areas surrounding the Lower Passaic River became a focal point for the industrial revolution in the United States. By the 20th century, Newark had established itself as the largest industrial-based city in the country. The urban and industrial development surrounding the Lower Passaic River, combined with associated population growth, have resulted in poor water quality, contaminated sediments, bans on fish and shellfish consumption, lost wetlands, and degraded habitat. Table 2.2-1 contains a history of events surrounding the Diamond Alkali Superfund Site and creation of the Study. While this chronology of events is significant to the project, the Diamond Alkali site is not the only source of contamination in the Lower Passaic River. It is important to understand that sediment contamination in the Lower Passaic River, and other problems being addressed by the partner agencies, came from numerous parties and sources over the past 100 years or more, including direct discharges via spills, runoff, groundwater migration and outfall pipes, as well as indirect discharges through sewers. Population growth and development pressures have also contributed to the degradation of the Lower Passaic River.

Table 2.2-1: Project History (modified from Malcolm Pirnie, Inc., 2006a)

Date	Activity
1940s	Manufacturing facility located at 80 Lister Avenue, Newark, New Jersey, begins producing DDT and phenoxy herbicides.
1951-69	Diamond Alkali Company (subsequently known as the Diamond Shamrock Chemicals Company) owns and operates a pesticides manufacturing facility at 80 Lister Avenue. In 1960, an explosion destroys several plant processes; also in 1960, production is limited to herbicides, including those used in the formulation of the defoliant "Agent Orange." Diamond Alkali Company ceases operations in 1969.
1976	Congress authorizes the USACE to begin flood control study for the Passaic River Basin under WRDA.
1982	NJDEP releases fishing advisories for reduced consumption of white perch and white catfish in the Passaic River. River abutting 80 Lister Avenue closed for commercial fishing of American eel and striped bass.
1983	NJDEP and USEPA collect samples; high levels of dioxin detected in the Passaic River and at 80 Lister Avenue property.
1984	NJDEP issues Administrative Order of Consent (AOC) to Diamond Shamrock Chemicals Company to perform investigation of 80 Lister Avenue. NJDEP issues an AOC to Diamond Shamrock Chemicals Company to perform cleanup of select dioxin-contaminated properties and to perform investigation of 120 Lister Avenue.
1984	Diamond Alkali site listed on National Priority List.
1985	Investigation results released to public. Cleanup options for 80 and 120 Lister Avenue properties detailed in feasibility study.
1986	NJDEP presents cleanup options to public.
1987	USEPA and NJDEP hold public meeting to discuss the Proposed Plan for cleanup. USEPA selects interim cleanup plan (Record of Decision) for the 80 and 120 Lister Avenue portion of the Diamond Alkali Superfund Site, requiring the containment of contaminated materials.
1988	Diamond Alkali Superfund Site transferred from state lead under NJDEP to federal lead under USEPA.
1990	The federal court approves a Consent Decree among Occidental Chemical Corporation (OCC), as successor to Diamond Shamrock Chemicals Company, and Chemical Land Holdings, Inc. [now known as Tierra Solutions, Inc. (TSI)] and USEPA and NJDEP to implement the 1987 interim cleanup plan.
1994	USEPA and OCC sign an AOC to investigate the lower six-mile stretch of the Passaic River. Demolition of buildings at 80 Lister Avenue is completed.
1995	Field work begins on the lower six-mile stretch of the Passaic River.

Date	Activity
1996-99	USEPA, at the request of the local community, explores the potential for implementing an alternative to the interim cleanup plan selected in 1987. Alternative plan not found. USEPA reviews and approves design of 1987 interim cleanup plan.
1999	Congress authorizes the Hudson-Raritan Estuary Study, and the Passaic River is added as a priority site under WRDA "Section 312 Environmental Dredging."
2000	Congress authorizes the USACE to conduct the Lower Passaic River Ecosystem Restoration Study under WRDA. USACE initiates a Reconnaissance Study for the Lower Passaic River.
2000	USEPA interim cleanup begins at land portion of Diamond Alkali site, which included installation of a cap, slurry wall, and flood wall around the properties and groundwater pumping and treatment.
2001	Interim cleanup completed at land portion of Diamond Alkali site. USACE completes Reconnaissance Study for the Lower Passaic River.
2002	Urban Rivers Restoration Initiative launched; USEPA and USACE sign National Memorandum of Understanding for the purpose of coordinating the planning and execution of urban river cleanup and restoration.
2003	Six-mile study of Lower Passaic River expanded to include the extent of contamination in the lower 17 miles of the Passaic River. State and federal trustees sign a Memorandum of Agreement for Natural Resource Damage Assessment and Restoration for the Diamond Alkali Superfund Site and environs. USEPA, USACE, and NJDOT sign a Project Management Plan for the Lower Passaic River Restoration Project. Feasibility cost sharing agreement signed by USACE and NJDOT. Selection of Passaic River as one of eight national pilot projects of the Urban Rivers Restoration Initiative.
2004	USEPA enters into an AOC with 31 Potentially Responsible Parties (PRPs) to fund Superfund portion of the Lower Passaic River Restoration Project.
2004	USEPA and TSI sign an AOC to investigate Newark Bay. TSI was the sole PRP in this AOC.
2005	Twelve additional PRPs were added to the AOC for the Superfund portion of the Lower Passaic River Restoration Project.
2007	USEPA enters into a new AOC which turns the 17-mile Study over to the Cooperating Party Group (CPG), which consists of 73 members.

The legal history of the Lower Passaic River Restoration Project extends back to 1994, during which the USEPA and OCC signed an AOC to investigate dioxin in a six-mile stretch of the Lower Passaic River. At that time, OCC was the sole PRP, and dioxin was the sole COPC. The six-mile stretch was termed the Passaic River Study Area (PRSA). As a result of the sediment sampling conducted by TSI on behalf of OCC under this AOC, the USEPA decided to expand the investigation to the entire 17 miles of the Lower Passaic River and to expand the COPCs to a larger suite of chemicals. This expansion marked the end of the six-mile PRSA. On June 22, 2004, the USEPA and 31 PRPs signed an AOC for the PRPs to fund USEPA's work on the 17-mile study area, and the COPC list was expanded further. In 2007, the PRP group (now known as the CPG) was expanded to 73 (Table 2.2-2), and the group took over the study of the 17-mile stretch with USEPA oversight.

Table 2.2-2: Members of the Cooperating Party Group

Number	Name of Cooperating Party
1	Alliance Chemical, Inc. on behalf of itself and Pfister Chemical, Inc.
2	Arkema, Inc.
3	Ashland, Inc.
4	Atlantic Richfield Company
5	BASF Corporation, on its own behalf and on behalf of BASF Catalysts, LLC
6	Belleville Industrial Center
7	Benjamin Moore & Co.
8	Bristol-Myers Squibb Company
9	CBS Corporation, a Delaware corporation, formerly known as (f/k/a) Viacom, Inc., successor by merger to CBS Corporation, a Pennsylvania corporation, f/k/a/ Westinghouse Electric Corporation
10	Celanese Ltd.
11	Chemtura Corporation and Raclaur, LLC as current and former owner or the property f/k/a Atlantic Industries
12	Chevron Environmental Management Company, for itself and on behalf of Texaco, Inc.
13	Coltec Industries
14	Conopco, Inc., doing business as Unilever (as successor to CPC/Bestfoods, former parent of the Penick Corporation (facility located at 540 New York Avenue, Lyndhurst, New Jersey)
15	Covanta Essex Company
16	Croda, Inc.
17	DiLorenzo Properties Company on behalf of itself and the Goldman/Goldman/DiLorenzo Properties Partnerships
18	E. I. du Pont de Nemours and Company

Number	Name of Cooperating Party
19	Eden Wood Corporation
20	Elan Chemical Company
21	EPEC Polymers, Inc. on behalf of itself and EPEC Oil Company Liquidating Trust
22	Essex Chemical Corporation
23	Flexon Industries Corp.
24	Franklin-Burlington Plastics, Inc.
25	Garfield Molding Co., Inc.
26	General Electric Company
27	General Motors Corporation
28	Givaudan Fragrances Corporation (Fragrances North America)
29	Goodrich Corporation of behalf of itself and Kalama Specialty Chemicals, Inc.
30	Hercules Chemical Company, Inc.
31	Hess Corporation, on its own behalf and on behalf of Atlantic Richfield Company
32	Hexcel Corporation
33	Hoffmann-La Roche, Inc. on its own behalf and on behalf of its affiliate Roche Diagnostics
34	Honeywell International, Inc.
35	ISP Chemicals, LLC
36	ITT Corporation
37	Kao Brands Company
38	Leemilt's Petroleum, Inc. (successor to Power Test of New Jersey, Inc.), on its behalf and on behalf of Power Test Realty Company Limited Partnership and Getty Properties Corp., the General Partner of Power Test Realty Company Limited Partnership
39	Lucent Technologies, Inc.
40	Mallinckrodt, Inc.
41	Millennium Chemicals, Inc. affiliated entities MHC, Inc. (on behalf of itself and Walter Kidde & Company, Inc.), Millennium Petrochemicals, Inc. (f/k/a Quantum Chemical Corporation) and Equistar Chemicals LP
42	National-Standard, LLC
43	Newell Rubbermaid, Inc., on behalf of itself and its wholly-owned subsidiaries Goody Products, Inc. and Berol Corporation (as successor by merger to Faber-Castell Corporation)
44	News Publishing Australia Ltd. (successor to Chris-Craft Industries)
45	Novelis Corporation (f/k/a Alcan Aluminum Corporation)
46	NPEC, Inc.
47	Occidental Chemical Corporation (as successor to Diamond Shamrock Chemicals Company)
48	Otis Elevator Company
49	Pfizer, Inc.

Number	Name of Cooperating Party
50	Pharmacia Corporation (f/k/a Monsanto Company)
51	PPG Industries, Inc.
52	Public Service Electric and Gas Company
53	Purdue Pharma Technologies, Inc.
54	Quality Carriers, Inc. as successor to Chemical Leaman Tank Lines, Inc., and its affiliates and parents
55	Reichhold, Inc.
56	Revere Smelting and Refining Corporation
57	Safety-Kleen Envirosystems Company by McKesson, and McKesson Corporation for itself
58	Sequa Corporation
59	Sun Chemical Corporation
60	Tate & Lyle Ingredients Americas, Inc. (f/k/a A. E. Staley Manufacturing Company, including its former division Staley Chemical Company)
61	Teva Pharmaceuticals USA, Inc. (f/k/a Biocraft Laboratories, Inc.)
62	Teval Corporation
63	Textron, Inc.
64	The BOC Group, Inc.
65	The Hartz Consumer Group, Inc., on behalf of The Hartz Mountain Corporation
66	The Newark Group
67	The Sherwin-Williams Company
68	The Stanley Works
69	Three County Volkswagen
70	Tiffany and Company
71	Vertellus Specialties, Inc. f/k/a Reilly Industries, Inc.
72	Vulcan Materials Company
73	Wyeth, on behalf of Shulton, Inc.

2.3 SCOPE AND ROLE OF RESPONSE ACTION

The 17-mile tidal portion of the Passaic River is an OU of the Diamond Alkali Superfund Site. Other OUs are: the manufacturing facility located at 80-120 Lister Avenue in Newark, New Jersey, which has an interim remedy in place; and Newark Bay (including portions of the Hackensack River, Arthur Kill and Kill Van Kull), which has its own RI/FS ongoing.

As noted above, sediments in the lower eight miles of the river, a portion of the 17-mile Passaic River OU, have been identified as a major source of contamination to the 17-mile Study Area and to Newark Bay, and an FFS has been undertaken to evaluate a range of remedial alternatives for an early action to control that major source. The Source Control Early Action will address contaminated sediments in the lower eight miles of the Passaic River (the Area of Focus) in order to more rapidly reduce risks to human health and the environment. Sediments in the Area of Focus consist of the predominantly fine-grained, contaminated sediment present in the Brackish and Transitional Sections[3] of the Lower Passaic River. Geomorphological data suggest fine-grained sediments exist in a contiguous stretch up to approximately RM8. While the preponderance of available contaminant data represents the area between RM1 and RM7, the CSM (Malcolm Pirnie, Inc., 2007a) suggests that RM0 to RM1 and RM7 to RM8 will behave similarly to the area between RM1 and RM7. The Source Control Early Action, which will be a final remedial action for the sediments in the lower eight miles, is intended to take place in the near term, while the comprehensive 17-mile Study is on-going.

2.4 SITE CHARACTERISTICS

A comprehensive CSM[4] built upon detailed geochemical data evaluations and the assimilation of various data sources has been developed for the Lower Passaic River. The CSM for the Study was initially presented in the August 2005 version of the Work Plan (Malcolm Pirnie, Inc., 2005c). This CSM has been updated as part of the FFS

[3] As described in the CSM (Malcolm Pirnie, Inc., 2007a), the Lower Passaic River may be divided into three sections: a Freshwater section (RM10 to RM17.4) dominated by freshwater flow entering over Dundee Dam, a Brackish section (RM0 to RM6) dominated by saline waters from Newark Bay, and a Transitional section (RM6 to RM10) where the two mix.

[4] A CSM expresses a site-specific contamination problem through a series of diagrams, figures, and narrative consistent with USEPA Office of Solid Waste and Emergency Response (OSWER) remedial investigation and feasibility study guidance (USEPA, 1988).

(Appendix A of the FFS; Malcolm Pirnie, Inc., 2007b). A summary of conclusions discussed in the CSM is presented below.

The CSMs specific to the HHRA and ERA are described in Section 2.6.1.1 "Risk Assessment Conceptual Site Model" and Section 2.6.2.2 "Ecological Exposure Assessment," respectively.

2.4.1 Site Overview

The Lower Passaic River is a partially stratified estuary where the degree of stratification and the location of the salt front at any point in time reflect a dynamic balance between the freshwater flow and the tidal exchange with Newark Bay. Tidal displacement in the Lower Passaic River is quite large, with the salt front moving several miles during each tidal cycle. The Lower Passaic River carries a large suspended solids load derived from upstream sources and Newark Bay, as well as mobilization of previously deposited solids due to tidal displacement.

The Lower Passaic River was one of the major centers of the American industrial revolution, with early manufacturing, particularly cotton mills, developing in the area around the Great Falls in Paterson, New Jersey. In subsequent years, a multitude of industrial operations developed along the banks of the Passaic River, as the cities of Newark and Paterson grew. These industrial operations included manufactured gas plants, paper manufacturing and recycling facilities, chemical manufacturing facilities, and others that used the river for wastewater disposal. Moreover, the Lower Passaic River has been used as a major means of conveyance for municipal sewage and storm water discharges from the middle of the nineteenth century to the present time. Ultimately, many contaminants were discharged to the Lower Passaic River, including persistent contaminants such as PCDD/F, PAHs, PCBs, pesticides, and heavy metals.

An important component of the region's development and urbanization was the deepening of the river to permit commercial vessels to travel to the city of Newark and farther upriver. Several large dredging projects were undertaken at the beginning of the twentieth century to create a navigation channel to approximately RM15. Since the 1940s, there has been little maintenance dredging above RM2. Consequently, extensive fine grained sediment deposits exist in the previously dredged channel, particularly between RM0 and RM8. The coincidence of contaminant discharges to the river and a significant suspended sediment load created an ideal situation for accumulating contaminated sediments. As a result, the river accumulated substantial sediment beds, measuring up to 25 feet thick in some areas. These thick sediment deposits remain, primarily below RM8 where the relatively wider river channel provided favorable conditions for rapid sediment accumulation. Much less accumulation has occurred upstream of RM8 because of the narrower channel. The change in river geometry is illustrated in Figure 2.4-1), which shows the relationship between location and the river's cross sectional area. The larger cross-sectional area is due primarily to the width of the river, with a larger cross-sectional area also implying a slower flow velocity.

Despite the prevalence of thick sediment deposits below RM8, the sediments in this region are not all stable, and erosional areas have been identified throughout the lower 8 miles of the river. These erosional areas are believed to be responsible for on-going releases of contaminant-bearing solids from the legacy sediments on the river bed. This is shown in Figure 2.4-2, which plots the fractions of depositional and erosional areas as a function of location (river mile), calculated for quarter-mile increments. A detailed examination of sediment deposition rates between RM1 and RM7 indicates a high degree of spatial heterogeneity, with local rates varying from about 6 inches/year of net erosion to about 8 inches/year of net deposition. Historical deposition rates were probably higher than current rates (and erosional areas fewer and smaller) because of the more extensive salt front intrusion and deeper channel depths immediately after the initial channel dredging, which would have enhanced settling of suspended sediment.

A comparison of current and historical mass balances of solids coming into the Lower Passaic River shows that the relative importance of the solids load coming from the head-of-tide has increased over the years, compared to that coming from Newark Bay. The current head-of-tide solids load to the Lower Passaic River is greater than the annual average rate of accumulation in the river; however, the historical rates of sediment accumulation in the Lower Passaic River were probably too large to be sustained solely by the Passaic's head-of-tide solids loads, suggesting that solids transport from Newark Bay may have supplied the additional solids.

2.4.2 Site Geology

The Lower Passaic River is situated within the Newark Basin portion of the Piedmont physiographic province, located between the Atlantic Coastal Plain Province and the Appalachian Plateau (Fenneman, 1938). The Newark Basin is underlain primarily by sedimentary rocks (sandstone, shale, calcareous shale, and conglomerate), to a lesser extent by igneous rocks (basalt and diabase), and may locally be underlain by metamorphic rocks (slate and schist). The Newark Basin rocks are from the mid-Triassic to early Jurassic periods. Bedrock underlying the Lower Passaic River is the Passaic Formation (Olsen *et al.*, 1984; Nichols, 1968), consisting of interbedded red-brown sandstone and shale.

Almost the entire Passaic River Basin, including the Lower Passaic River, was subjected to glacial erosion and deposition as a result of the last Wisconsin glaciation stage. Considerable quantities of stratified sand, silt, gravel, and clay were deposited throughout the area. These glaciofluvial deposits, in the form of glacial lake sediments, overlie bedrock and underlie the Meadowlands section of Newark Basin.

Sediment sampling programs conducted in the Lower Passaic River have typically encountered deposits of silt overlying sequences of sand and, in some cases, red-brown clay. The thickness of the silt deposit in a given location has been shown to correlate well with the depth of the constructed navigation channel at that location, suggesting that the navigation channel was constructed by dredging into the sand sequence.

2.4.3 Surface Water Hydrology

The Lower Passaic River and the Hudson-Raritan Estuary are a unique hydrologic system that encompasses a major metropolitan area in the United States, including two major cities: New York City, New York and Newark, New Jersey. Since the American industrial revolution, this area has experienced significant urbanization and industrial development, which has consequently impacted the surrounding ecosystems and waterways. Discharges of industrial waste and municipal sewage have degraded sediment and water quality in the estuary. As contaminated solids and water enter the system, they are diluted and are disseminated throughout the estuary by the incoming and outgoing tides. These tides cause twice-daily mixing of surficial sediments through the resuspension and redeposition of solids. Over time, solids that originated from one end of the estuary (*e.g.*, the Lower Passaic River) are transported to other regions of the estuary (*e.g.*, the Hudson River).

Dundee Dam (located at RM17.4) divides the Upper Passaic River from the Lower Passaic River (Figure 2.1-1). The Upper Passaic River meanders across several geologic settings, draining urban, suburban, and rural portions of northeastern New Jersey. The Upper Passaic River watershed includes 16 Superfund sites and 2,216 New Jersey Known Contaminated Sites. Soils and groundwater at these sites are contaminated with an array of chemicals.

The Lower Passaic River is divided into three river sections, as noted above in Section 2.3 "Scope and Role of Response Action" (see footnote), and is bounded by the Dundee Dam and Newark Bay (Figure 2.4-3). In general, freshwater and solids flow over the Dundee Dam, enter the Freshwater River Section, and flow downriver to Newark Bay. Freshwater from the Lower Passaic River flows downriver over the salt wedge to Newark Bay. Saline water from Newark Bay moves upriver beneath the freshwater flow. The mixing of fresh and saline waters creates the Brackish and Transitional River Sections. Solids originating above the dam, solids eroding along the length of the lower river, solids transported upriver from Newark Bay, and those solids discharged from other sites (including combined sewer overflows (CSOs) and tributaries) are continuously mixed by tidal action, resuspending and redepositing surface sediment. These processes cause the continuous re-working of fine-grained sediments on the surface of the river bed.

Dated sediment cores that document the magnitude of the historical contaminant concentration to the Lower Passaic River record similar concentration histories, despite the distance separating the cores. This observation is direct evidence of the effectiveness of tidal mixing in the Lower Passaic River, where sediments are well homogenized prior to deposition. Moreover, the presence or absence of an interval of high concentration within the sediments at a given location is a function of the depositional history and is not controlled by proximity to source. Thus, thick sequences of contaminated sediments will tend to have similar inventories of contaminants throughout the Brackish River Section and even into the Transitional River Section of the river.

2.4.4 Sediment Characteristics

2.4.4.1 Data Sources Used to Characterize Sediments

Numerous data sources were considered and utilized in the various data analysis and modeling efforts on which the analysis of the remedial alternatives was based. Table 2.4-1 summarizes the data sets presented in the CSM (Malcolm Pirnie, Inc., 2007a) that were used to develop a thorough understanding of site characteristics and site processes. These data sets were supplemented with literature data that are referenced in the CSM.

Table 2.4-1: Data Sets Presented in the CSM (Malcolm Pirnie, Inc., 2007a)

Study Name [1]	Sample Year	Number of Locations	River Mile or Water Body	Type of Sample
1990 Surficial Sediment Investigation	1990	3 [2]	Above Dundee Dam	Sediment Grab
1991 Core Sediment Investigation	1991	1 [2]	Above Dundee Dam	Sediment Core [3]

Study Name [1]	Sample Year	Number of Locations	River Mile or Water Body	Type of Sample
1995 Remedial Investigation Sampling Program	1995	97	RM0.9 to RM6.8	Sediment Core [3],[4]
1999 Sediment Sampling Program	1999	1 [5]	RM6.2	Sediment Core [3]
1999 Late Summer/Early Fall Environmental Sampling Program	1999	45	RM1 to RM6.9	Sediment Grab
1999/2000 Minish Park Monitoring Program	1999	8	RM4.9 to RM5.1	Sediment Core [3]
2000 Spring Environmental Sampling Program	2000	15	RM1 to RM6.9	Sediment Grab
Newark Bay 2005 Remedial Investigation Work Plan Phase 1 Dataset	2005	69	Newark Bay	Sediment Core [3]
2005-2006 USEPA Sampling Program High Resolution Cores	2005	5	RM1.4 to RM12.6	Sediment Core [3],[4]
2005-2006 USEPA Sampling Program Low Resolution Cores	2006	10	RM2.8 to RM6.8	Sediment Core [3]

[1] Data are available at www.ourPassaic.org.
[2] Only sample locations above the Dundee Dam were evaluated.
[3] Only surface sediment samples are presented in the CSM.
[4] All data from sediment core were evaluated to develop the CSM.
[5] Only one sampling location was incorporated into CSM since the other samples were mis-projected.

Table 2.4-2 provides an additional list of data sets evaluated in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c). The conclusions from these evaluations were summarized and presented throughout the CSM.

Table 2.4-2: Data Sets Referenced in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c)

Study Name [1]	Sample Year	Number of Locations	River Mile or Water Body	Type of Sample
1990 Surficial Sediment Investigation	1990	2 [2]	RM3.2 to RM7	Sediment Grab
1991 Core Sediment Investigation	1991	14 [2]	RM0.2 to 7	Sediment Core [3]
2004 Newark Bay Remedial Investigation Work Plan	1991-1998	32	Newark Bay	Sediment Core [4]
1992 Core Sediment Investigation	1992	4 [2]	RM1.1 to RM7	Sediment Core [4]
1993 Core Sediment Investigation – Part 1 (March 1993)	1993	8 [2]	RM0.3 to RM7	Sediment Core [3]
1993 Core Sediment Investigation – Part 2 (July 1993)	1993	11	RM0.5 to RM3	Sediment Core [3]

Study Name [1]	Sample Year	Number of Locations	River Mile or Water Body	Type of Sample
1994 Surficial Sediment Investigation	1994	18 [2]	RM3.5 to RM7.8	Sediment Grab
1995 Remedial Investigation Sampling Program	1995	97	RM1 to RM6.8	Sediment Core [3]
1995 Sediment Grab Sampling Program	1995	7	RM2.4 to RM2.7	Sediment Grab
1995 USACE Minish Park Investigation	1995	10	RM3.7 to RM5.5	Sediment Core [3]
1996 Newark Bay Reach A Sediment Sampling Program	1996	4	Newark Bay	Sediment Core [4]
1998 Newark Bay Elizabeth Channel Sampling Program	1998	3	Newark Bay	Sediment Grab and Sediment Core [4]
1999 Late Summer/Early Fall Environmental Sampling Program	1999	45	RM1 to RM6.9	Sediment Grab
1999 Newark Bay Reach ABCD Baseline Sampling Program	1999	10	Newark Bay	Sediment Grab
1999 Sediment Sampling Program	1999	1 [5]	RM6.2	Sediment Core [4]
1999/2000 Minish Park Monitoring Program	1999	8	RM4.9 to RM5.1	Sediment Core [4]
2000 Spring Environmental Sampling Program	2000	15	RM1 to RM6.9	Sediment Grab

[1] Data are available at www.ourPassaic.org.
[2] Only sampling locations between RM0 and RM7 were evaluated.
[3] All data from the sediment core were evaluated in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c).
[4] Only surface sediment samples were evaluated in the Draft Geochemical Evaluation (Step 2).
[5] Only one sampling location was incorporated into Draft Geochemical Evaluation (Step 2) since the other samples were mis-projected.

The specific, refined sampling efforts that were used in the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b) to quantify the contribution of the various sources of contamination to the Lower Passaic River are discussed in Section 2.4.6.1 “Empirical Mass Balance Model.”

In addition to the data sets presented above, it is important to note that numerous non-chemical data sets (*e.g.*, bathymetry data, data obtained from geotechnical sediment cores, sediment texture data) have been critical in refining the understanding of site processes.

High resolution sediment cores (or "dated sediment cores"; listed in Table 2.4-1 and Table 2.4-7) have played an integral role in the geochemical evaluations and mass balance modeling efforts to date. Data from these cores have proven to be a powerful tool and have been used extensively. High resolution sediment cores document the history of contaminant inputs, transport, and transformation. Differences among contaminant histories in high resolution sediment core records can document the introduction and approximate location of contaminant sources. High resolution sediment cores can document the degree to which contaminated sediments are mobilized in the river during extreme flows; this is critical in evaluating remedial alternatives. Additionally, contaminant histories and associations derived from high resolution sediment cores can provide a basis to limit future analytical costs (Malcolm Pirnie, Inc., 2005c).

To summarize their importance, high resolution sediment cores can help to:

- Understand contaminant distribution in the Lower Passaic River as a function of distance along the river.

- Understand the long-term fate of contaminants within the sediments, such as long-term transformation processes.

- Document the effects of past events, such as the impacts of major storm events, on sediment beds (as an empirical indicator of sediment stability during extreme events) and the introduction of contaminants to the river.

- Provide data on time-dependent functions (*e.g.*, mixing and source inputs).

- Augment the calculation of contaminant mass and sediment volumes based on finer sampling intervals and more accurate estimation of sedimentation rates than can be achieved by low resolution sediment cores and bathymetric surveys alone, since these cannot provide a complete historical picture of the contaminant inputs or accumulation.

- Provide additional data to understand the complex interactions of contaminants, sediments, time, river flow and tide, and adjacent water bodies.

- Provide information on current sources and loads as context for assessing the effectiveness of remedial alternatives, including providing a basis to evaluate the potential for recontamination from adjacent water bodies.

2.4.4.2 COPCs and COPECs in Sediments

The list of COPCs and COPECs in the sediments of the Lower Passaic River was developed for the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) and is summarized in Table 2.4-3.

Types and characteristics of COPCs and COPECs (e.g., toxic, carcinogenic, non-carcinogenic) are discussed Section 2.6.1.2 “Types and Characteristics of Contaminants of Potential Concern.”

Table 2.4-3: COPCs and COPECs in the Sediments of the Lower Passaic River

Analyte	Human Health COPC	Ecological COPEC
Inorganic Compounds		
Copper		✓
Lead		✓
Mercury	✓	✓
Semivolatile Organic Compounds (PAHs)		
LMW PAH [1]		✓
HMW PAH [2]		✓
PCBs		
Total PCBs (sum of Aroclors)	✓	✓
Pesticides/Herbicides		

Analyte	Human Health COPC	Ecological COPEC
Chlordane	✓	
Dieldrin	✓	✓
DDD [3]	✓	
DDE [3]	✓	
DDT [3]	✓	
Total DDT [3]		✓
PCDD/F		
2,3,7,8-TCDD	✓	✓
TCDD TEQ for PCDD/F	✓	✓
TCDD TEQ for PCBs	✓	✓

[1] LMW PAH is defined as the sum of acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene. Samples flagged as not detected are incorporated into the summation as zero.
[2] HMW PAH is defined as the sum of benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, indeno[1,2,3-c,d]pyrene, and pyrene. Samples flagged as not detected are incorporated into the summation as zero. Total PAH is the sum of HMW PAH and LMW PAH.
[3] DDD, DDE, and DDT refers only to the 4,4'-isomers. Total DDT is defined as the sum of DDD, DDE, and DDT.

2.4.4.3 Nature and Extent of Sediment Contamination

One important observation from the lateral and vertical extent of chemical contamination in the Lower Passaic River is the extent of tidal mixing throughout the river. Concurrently-deposited sediments throughout the Lower Passaic River have very similar concentrations of contaminants, indicating that sediments are well-homogenized prior to deposition. Thus, the presence or absence of an interval of high concentration within the sediments at a given location is a function of the depositional history at that location and is generally not controlled by proximity to source. As a result, thick sequences of contaminated sediments will tend to have similar inventories of contaminants regardless of their location in the river, as illustrated by Lower Passaic River dated sediment core profiles for 2,3,7,8-TCDD (Figure 2.4-4) and Total PCBs (Figure 2.4-5). Note that these figures are just two examples of 31 figures presented in the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007).

Contaminant inventories (*i.e.*, mass, not concentration) are not evenly distributed and vary along the length of the Lower Passaic River, with maximum values occurring near the areas encompassing RM1 to RM2, RM3 to RM4, and RM6 to RM7 (Figure 2.4-6). The coring data that form the basis for these inventories show a high degree of local spatial heterogeneity, indicating that discrete areas of relatively higher concentrations typically described as "hot spots" likely do not exist. Instead, the data indicate the presence of "hot zones" of the river on the scale of a mile or more, nearly bank to bank (*i.e.*, the width of the navigation channel plus historical berth areas) in lateral extent. This conclusion does not, however, diminish the significance of potential historic or current point sources as the origin of contaminant inventory in the Lower Passaic River. Estuarine mechanisms are believed to quickly render contaminant concentration gradients indistinct on the scales examined here. If very localized gradients in the sediment need to be identified, it is possible that environmental sampling on a finer scale (on the order of less than a quarter mile) might be necessary.

The legacy of sediment contamination in the Lower Passaic River likely extends back at least to the mid-nineteenth century, as illustrated by the vertical extent of contamination in the sediments. The oldest contaminants found in the sediments are PAH compounds, cadmium, mercury, and lead, which probably pre-date the turn of the twentieth century. Following these contaminants are, in order of chronological appearance in the river, DDT; 2,3,7,8-TCDD; and PCB. Other contaminants, such as arsenic, chromium, and copper are also present in the sediment record. The vertical extent of these contaminants is illustrated schematically in Figure 2.4-7. Details of the geochronology of these chemical classes and the patterns in surface sediment concentration are further described below.

2.4.4.3.1 History of Sediment Contamination: Summary of Sediment Geochronological Analysis

Dated sediment cores for the Lower Passaic River (RM1 to RM7) from the 1995 TSI data set show that the major releases of 2,3,7,8-TCDD began in the late 1940s to early 1950s and peaked in the late 1950s to early 1960s. The diagnostic ratio of 2,3,7,8-TCDD/Total TCDD of 0.7 to 0.8 can be used to trace Lower Passaic River PCDD throughout the Newark Bay complex and over the last 60 years. Based on dated sediment cores, this diagnostic ratio is observed throughout the sediments of the Lower Passaic River as far back as the 1950s. Prior to 1950, however, the 2,3,7,8-TCDD/Total TCDD ratio declines to a value of 0.1, approaching the value of 0.06, which is characteristic of sewage and atmospheric fallout (Chaky, 2003). The 2006 low resolution sediment cores indicated that 2,3,7,8-TCDD is not detected in the sand layer underlying the fine-grained sediment beds.

Dated sediment cores reveal that Total DDT discharges to the Lower Passaic River began in the 1930s and peaked in the late 1940s or early 1950s, consistent with the observations of Bopp *et al.* (1991a). Results consistently show measurable Total DDT concentrations occurring deeper in a sediment core than measurable 2,3,7,8-TCDD concentrations.

Total PCB contamination is distributed throughout the Lower Passaic River with peak concentrations [4 to 18 milligrams per kilogram (mg/kg)] occurring in the sediments dating to the 1960s or later. Hence, the extent of Total PCB contamination in the sediment beds is shallow when compared to mercury, lead, 2,3,7,8-TCDD, and Total DDT. Aroclor 1248 is the most commonly reported PCB mixture, typically comprising 60 percent or more of the Total PCB concentration.

Total PAH contamination is unique in its temporal distribution, with the highest concentrations observed in the deepest core layers, gradually declining to the most recent deposition. The presence of Total PAH contamination in the sand layer underneath the thick silt deposits may represent historic deposition or alternatively a contaminated groundwater source. Ratio analysis of Total PAH shows that the majority of PAH contamination in the sediments is derived from combustion-related processes (Malcolm Pirnie, Inc., 2006c), including coal tar residue (a by-product of manufactured gas plant processes) and urban background combustion. Of these combustion-related processes, coal tar wastes are historically the dominant source to the Lower Passaic River based on the prevalence of coal tar-like PAH ratios in more-contaminated sediments. The same analysis essentially rules out creosote-derived contamination and suggests that only minor portions of the sediment PAH contamination are derived from a petrogenic source (*e.g.*, oil spills).

Dated sediment cores from the TSI 1995 data set indicate that major contamination of heavy metals likely occurred in the 1930s or earlier. Elevated concentrations of arsenic (approximately 60 mg/kg), chromium (approximately 800 mg/kg), copper (approximately 700 mg/kg), and lead (approximately 700 mg/kg) occur at depth in dated sediment cores, usually reaching a maximum at core bottoms. This evidence indicates that the vertical extent of these contaminants is undefined and that, potentially, major inventories of these contaminants lie below the documented depth of 2,3,7,8-TCDD contamination. Dated sediment cores were also unable to establish the depth of contamination for mercury and cadmium; however, the analysis of 2006 low resolution sediment cores indicated that the sand layer underneath the fine-grained sediment beds was contaminated with mercury as well as other metals. The presence of mercury and the other contaminants at this depth suggests that they may have been present in the Lower Passaic River since the time of the original construction of the navigational channel.

2.4.4.3.2 Sediment Concentrations

Patterns and trends in surface sediment concentrations based on the 1995 TSI data set were presented in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c). For the 1995 data set, most of the contaminants examined have no trend, yielding no evidence to suggest multiple sources within the Lower Passaic River. The concentrations of three metals (arsenic, chromium, and mercury) statistically increased in the downriver direction, suggesting the possibility of two sources, one at each end of the Lower Passaic River (*i.e.*, a possible second source downriver of the original source may be contributing to the observed downriver increase in metal concentrations). Meanwhile, lead and PAH had a statistically decreasing trend downriver, suggesting that their primary source exists upriver of RM 7. However, while trends were identified in these data sets, low regression coefficients and high variability only weakly support the presence of a second source with typical concentration changes of 50 percent or less. For most contaminants, tidal mixing is sufficient to homogenize the impacts of local loads, resulting in no significant gradients in the Lower Passaic River.

The EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b) used a specific set of contaminants (including contaminants other than COPCs and COPECs as appropriate) to further characterize the Study Area. The average surface sediment concentrations of select contaminants (as presented in the EMBM) in recently deposited sediments are presented in Table 2.4-4. [Note that a separate set of average surface sediment concentrations were calculated as part of the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b); these data are not presented here.]

The data in Table 2.4-4 are derived from analysis of the top segments of five high-resolution sediment cores collected at various locations in the river. Recently-deposited surface sediments in the Lower Passaic River are defined as those deposited during the 2003-2005 time period. Table 2.4-4 also presents length-weighted average (LWA) concentrations of select contaminants in the Lower Passaic River using down-core data from the same five sediment cores. LWA concentrations represent a method of describing concentrations potentially available for resuspension. LWA concentrations integrate the entire thickness of contaminated sediments into one value for each contaminant, equivalent to the river eroding and resuspending sediment from all possible historical sediment layers on a roughly equal basis. [The EMBM (Appendix D of the

FFS; Malcolm Pirnie, Inc., 2007b) provides more detail on the calculation of average surface sediment concentrations and LWA concentrations.]

Table 2.4-4: Lower Passaic River Average Surface Sediment Concentrations and LWA Concentrations for Select Contaminants (modified from Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b)

Analyte	Average Surface Sediment Concentration (RM1.4, RM2.2, RM7.8, RM11, and RM12.6) (1)	LWA Concentration
Mercury (mg/kg)	1.8	5.7
Lead (mg/kg)	210	420
Cadmium (mg/kg)	3.6	11
Trans-Chlordane (µg/kg)	33	44
DDE (µg/kg)	54	200
2,3,7,8-TCDD (ng/kg)	280 (2)	3,600 (2)
Total TCDD (ng/kg)	420 (2)	4,100 (2)
BZ (3) 31 (µg/kg)	26	270 (2)
BZ 52 (µg/kg)	35	270 (2)
BZ 61+66+70+74+76 (µg/kg)	85	640 (2)
BZ 83+99 (µg/kg)	21	110 (2)
BZ 90+101+113 (µg/kg)	34	180 (2)
BZ 93+95+98+100+102 (µg/kg)	28	150 (2)
BZ 110+111+115 (µg/kg)	35	190 (2)
BZ 129+138+158+160+163+164 (µg/kg)	45	170 (2)
BZ 139+140+147+149 (µg/kg)	34	130 (2)
BZ 170 (µg/kg)	11	33 (2)
BZ 180+193 (µg/kg)	27	80 (2)
Benz[a]anthracene (mg/kg)	3.1	3.7
Benzo[a]pyrene (mg/kg)	3.6	3.7
Chrysene (mg/kg)	4.3	5.1
Fluoranthene (mg/kg)	6.5	8.2
Indeno[1,2,3-cd]pyrene (mg/kg)	2.9	2.6
Pyrene (mg/kg)	6.1	7.9

µg/kg – microgram per kilogram
ng/kg – nanogram per kilogram
(1) RI/FS river mile system is used.
(2) Average concentration for only three river locations (RM1.4, RM2.2, and RM11). RI/FS river mile system is used.

[3] BZ is the Ballschmiter and Zell (1980) system for PCB congener nomenclature in which congeners are arranged in ascending numerical order based on the number of chlorine atoms and their substitution pattern on the biphenyl base structure. The BZ system of PCB shorthand notation was subsequently recognized by the International Union of Pure and Applied Chemistry and is the generally accepted notation used by scientists who perform congener-specific PCB research.
Concentrations rounded to two significant figures, whenever possible.

2.4.4.4 Sources of Sediment and Contamination

An empirical mass balance approach (see Section 2.4.6.1 "Empirical Mass Balance Model") was used to understand the relative importance of the sources of sediment and associated contamination to the Lower Passaic River. Surface sediments that accumulate in the Lower Passaic River are comprised of solids that originated from the Upper Passaic River (located above the Dundee Dam), Newark Bay, major tributaries (including the Saddle River, Second River, and Third River), CSOs and stormwater outfalls (SWOs), and river-bottom sediment resuspension (Figure 2.4-8). In general, external contaminant sources (by themselves) cannot account for the observed COPC concentrations in Lower Passaic River surface sediments, indicating that an internal source, or more specifically, resuspension of legacy sediments, is contributing to the contaminant burden of recently deposited surface sediments in the river (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b). As a fraction of the total solids flux to the Lower Passaic River, resuspension of legacy sediments (*i.e.*, the historical inventory; referred to as Lower Passaic River Integrated Sediment) comprises about 10 percent of the total annual deposition. The relative contributions from the Upper Passaic River and Newark Bay are roughly equal with respect to solids, comprising approximately 40 percent each. In terms of the contaminant loads, however, the Upper Passaic River is clearly the more important of the two (see below). Tributaries and CSO/SWOs account for the remaining 10 percent of solids contribution to the Lower Passaic River.

As part of the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b), ratio analysis of several organic constituents has permitted the "fingerprinting" of the source material. Using these techniques, 2,3,7,8-TCDD contamination is shown to be derived almost exclusively from resuspension of legacy sediments (which were contaminated by historical industrial discharges) in the Lower Passaic River (Figure 2.4-9). Results of the EMBM indicate that the Upper Passaic River is the dominant source of PAH compounds to the Lower Passaic River, accounting for at least 50 percent of the contaminant load and often much more [as illustrated by benzo[a]pyrene and fluoranthene (both HMW PAH compounds); Figure 2.4-10 and Figure 2.4-11]. PAH patterns indicate that the majority of PAH contamination in the sediments is derived from combustion-related processes, particularly coal tar waste. For PCB, there are two main sources to the Lower Passaic River of roughly equal magnitude. The resuspension of legacy sediments contributes a mixture of LMW PCB congeners (as illustrated by BZ 52; Figure 2.4-12) while the flow from the Upper Passaic River contributes a higher molecular weight PCB mixture (as illustrated by BZ 180+193; Figure 2.4-13). The combination of the resuspension of legacy sediments and the flow from the Upper Passaic River account for nearly 75 percent (approximately 50 percent from resuspension and approximately 25 percent from Upper Passaic River flow) of the DDE contaminant burden to the river (Figure 2.4-14). Sources of mercury contamination to the Lower Passaic River are similar to those for DDE (Figure 2.4-15). The mass balance for lead indicates roughly equal contaminant contributions from five sources (resuspension of legacy sediments, flow from the Upper Passaic River, flow from Newark Bay, flow from major tributaries, and CSO/SWO discharges), approximately 20 percent each (Figure 2.4-16).

The CSM demonstrates that toxic constituent concentrations in the water column (*i.e.*, dissolved concentrations) and in biota (*i.e.*, tissue concentrations) of the Lower Passaic River are largely driven by solid-bound contamination (*i.e.*, associated with sediments and resuspended solids), particularly for 2,3,7,8-TCDD (Malcolm Pirnie, Inc., 2007a). While on-going external inputs exist, solid-bound concentrations are responsible for much of the dissolved contamination within the water column.

2.4.4.5 Estimated Volume of Contaminated Sediment and Associated Mass of Contaminants

The combination of the navigational dredging activities and the long and extensive history of contaminant discharges to the Lower Passaic River have served to create a uniquely large inventory of highly contaminated sediments contained within a relatively small area. Other major Superfund sites may have similar volumes of contaminated sediments [*e.g.*, Hudson River PCB site at 2.6 million cy (USEPA, 2002c) and Fox River PCB site at 8 million cy (USEPA, 2003b)], but these inventories are spread over much greater distances than the eight miles of the Lower Passaic River. While data are not sufficient to assess the volume of contaminated sediment for the entire Lower Passaic River, the volume is estimated at 5 to 8 million cy for RM0.9 to RM7, with an average depth of contamination ranging from 7 to 13 feet. The evidence from sidescan sonar and bathymetric surveys suggests that the conditions observed in RM0.9 to RM7 probably also apply over the area of RM0 to RM8, suggesting that the actual inventory of contaminated sediments is at least one-third greater than the values obtained in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c). Extrapolation of the estimated contaminant sediment volume into RM0 to RM1 and RM7 to RM8 results in an estimate of 6 to 10 million cy of contaminated sediment in RM0 to RM8.

The volume of 2,3,7,8-TCDD-contaminated sediments is somewhat smaller than the overall contaminated sediment volume, since several contaminants are present at greater depths than 2,3,7,8-TCDD. The estimate of 2,3,7,8-TCDD-contaminated sediment volume ranges from 5 to 6.5 million cy for RM0.9 to RM7.

The mass of contaminants contained within the sediments is also quite large (Table 2.4-5). Moreover, the mass of 2,3,7,8-TCDD represents one of the largest site inventories in the United States.

Table 2.4-5: Summary of Contaminant Inventory Estimates for RM0.9 to RM7

Inventory Estimate [1]	Total DDT (metric tons)	2,3,7,8-TCDD (metric tons)	Mercury (metric tons)	Total PCB (metric tons)
Based on measured core intervals only	6.4	0.020	24	6
Based on measured and extrapolated core profiles	11	0.029	37	8
Percent Increase [2]	72 percent	45 percent	54 percent	33 percent

[1] Based on information provided in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c).
[2] Percent increase is relative to the extrapolated mass estimate (*i.e.*, the second row of the table).

2.4.4.6 RCRA Hazardous Wastes and Affected Media

On-site remedial actions conducted under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) must comply with (or receive a waiver for) requirements of the Resource Conservation and Recovery Act (RCRA) that are determined to be ARARs. The USEPA has determined that sediments from the Lower Passaic River do not contain a listed hazardous waste. Thus, a data analysis was performed as part of the FFS (Malcolm Pirnie, Inc., 2007b) to determine whether sediment from the Lower Passaic River could be classified as a characteristic waste due to toxicity as defined through the Toxicity Characteristic Leaching Procedure (TCLP).

TCLP data are not available for Lower Passaic River sediments. However, in lieu of the TCLP extraction, Section 1.2 of the TCLP procedure (USEPA Method 1311; USEPA, 1992) allows for a total constituent analysis which may be divided by 20 to convert total results into the maximum hypothetical leachable concentration. This factor is derived from the 20:1 liquid-to-solid ratio employed in the TCLP method. Additional information on the use of the total constituent analysis in lieu of the TCLP method is described in the USEPA's "Monthly Hotline Report: Hotline Questions and Answers"

(1994). The total constituent analysis was performed on maximum sediment concentrations from Lower Passaic River sediment cores collected in 1991, 1993, and 1995. Appendix H of the FFS (Malcolm Pirnie, Inc., 2007b) contains further detail on the methodology and the results of this analysis. The results are summarized in Table 2.4-6.

Table 2.4-6: Percentage of Sediment Samples that Could Exceed Toxicity Characteristic Thresholds for Various Analytes

Contaminant	Exceedance Percentage	TCLP Threshold (mg/L)
1,4-Dichlorobenzene	2.5	7.5
2,4,6-Trichlorophenol	0.14	2
2,4-D	0.18	10
2,4-Dinitrotoluene	0.14	0.13
Arsenic	1.5	5
Cadmium	13	1
Chlordane	0.14	0.03
Chromium	73	5
Endrin	0.28	0.02
Hexachlorobenzene	0.66	0.13
Lead	83	5
Mercury	53	0.2
Selenium	0.15	1

mg/L = milligrams per liter

The analysis concluded that there is a reasonable probability that some sediment from the Lower Passaic River could exceed toxicity characteristic criteria if the TCLP test were performed; this likelihood has been accounted for in development of scenarios for dredged material management. In particular, based on this analysis, the analytes most likely to exceed the toxicity characteristic thresholds are chromium, lead, and mercury. However, it has not yet been determined whether sediment from the Lower Passaic River will, in fact, be classified as a RCRA hazardous waste; this must be resolved by further investigation during design.

2.4.4.7 Impacts of the Lower Passaic River to Newark Bay

The Lower Passaic River is the main source of freshwater to Newark Bay and a major source of contaminants to the Bay as well. Solids delivered from the Lower Passaic River to Newark Bay contain contaminant levels similar to those found in surficial sediments of the Lower Passaic River. As a result, for several contaminants examined, the history of contamination observed in the Lower Passaic sediments is also observed in Newark Bay. For example, dated sediment cores for the Lower Passaic River (RM0.9 to RM7) are consistent with the observations by Bopp *et al.* (1991a and 1991b) and Chaky (2003) for Newark Bay, specifically that the major releases of 2,3,7,8-TCDD begin in the late 1940s to early 1950s and peak around the late 1950s to early 1960s. The history of Total DDT releases observed in the Lower Passaic River was also consistent with the observations for Newark Bay made by Bopp *et al*. The diagnostic ratio of 2,3,7,8-TCDD/Total TCDD of 0.7 to 0.8 can be used to trace Lower Passaic River 2,3,7,8-TCDD contamination throughout the Newark Bay complex. Recent surficial samples from Newark Bay suggest the mixing of high ratio, high 2,3,7,8,-TCDD concentration sediments from the Lower Passaic River with somewhat lower ratio, lower concentration sediments from the Arthur Kill and Kill van Kull, creating gradients in the ratio and the 2,3,7,8,-TCDD concentration across Newark Bay.

Mass balance analyses performed on Newark Bay suggests that the Lower Passaic River contributes approximately 10 percent of the total amount of solids accumulating in Newark Bay, but more than 80 percent of the 2,3,7,8-TCDD accumulating in the Bay (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b). No other single source delivers more than 10 percent of the total 2,3,7,8-TCDD load. A similar mass balance analysis for mercury shows that the Lower Passaic River sediments are responsible for approximately 20 percent of the total mercury load to Newark Bay.

2.4.5 Groundwater and Surface Water Contamination

Investigations to date and the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b) focused on sediment solids and chemicals that are predominantly associated with sediments. Because the COPCs and COPECs that are under consideration are particle-reactive and are dominantly transported when sorbed to solids, contaminated sediments are the probable source of these compounds in the surface water of the Lower Passaic River. For this reason, remediation of sediment contaminated by COPCs and COPECs through the Source Control Early Action will likely effect a significant decrease in dissolved concentrations of these contaminants. The importance of groundwater and other releases of contamination that can only contribute dissolved phase constituents were not evaluated.

2.4.6 Models Used to Further the CSM

2.4.6.1 Empirical Mass Balance Model

A chemical mass balance approach similar to USEPA's Chemical Mass Balance (CMB) model (Watson *et al.*, 2004) was used for the Lower Passaic River EMBM Analysis. The USEPA CMB model is applied in air pollution studies for particulate matter and volatile organic compounds. Recently, CMB type-formulated models have been applied to sediment contamination sites that are contaminated with PCB, PCDD/F, and PAH compounds. Examples of these sediment contamination sites include Fox River in Wisconsin (Su *et al.*, 2000), Ashtabula River in Ohio (Imamoglu *et al*., 2002), Lake Calumet in Chicago (Bzdusek *et al.*, 2004), and Tokyo Bay and Lake Shinji in Japan (Ogura *et al.*, 2005).

The input parameters to the EMBM were the measured concentrations of the various chemicals in the different sources of contamination to the Lower Passaic River. Furthermore, watershed solids yield and watershed areas available from the United States Geological Survey (USGS) were used to formulate model constraints. The chemical signatures of the contamination sources were derived from several data collection programs, which are listed in Table 2.4-7.

Table 2.4-7: Field Sampling Programs Considered in the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b)

Source or Receptor	Field Sampling Program Considered	Number of Locations
Lower Passaic River	2005 USEPA High Resolution Sediment Coring Program	5
	2005 USEPA Large Volume Water Column Program	1
	2005 USGS Water Monitoring Data (collected during the NJDOT Environmental Dredging Pilot Study)	2
Newark Bay	2005 TSI Remedial Investigation Phase 1 dataset	16
Dundee Dam	2007 USEPA Sediment Coring Program	1
Tributaries	2005 USEPA Semi-permeable Membrane Device (SPMD) Deployments	4
	2005 USEPA Small Volume Water Column Program	4
CSO/SWOs	2001-2004 Contaminant Assessment and Reduction Program dataset	8

The uncertainty and variability in the measured concentrations used in the EMBM (both source profiles and receptor concentrations) were evaluated using a one-dimension Monte Carlo approach, which was used to examine the range of solids contributions presented in Figure 2.4-8. In this approach, a distribution was specified for each concentration based on the observed values, and the mass balance calculations were repeated 5000 times using randomly selected concentrations for the sources and receptor. The results from the assumption of normal distribution were similar to those obtained from the log-normal simulation. The average percent solids contribution from the simulation results are consistent with the results obtained from Solver^{TM} based on the average LWA concentrations in sediments. In general, the Monte Carlo analysis results indicated that resuspension of legacy sediments varies from 5 to 15 percent of the total solids contribution, the solids contribution from the Upper Passaic River is similar to that from Newark Bay (each contributing approximately 40 percent), and the solids contribution from major tributaries is similar to that from CSO/SWOs (each contributing approximately 5 percent).

On the face of it, the major conclusion from the EMBM is that the legacy sediments of the Lower Passaic River and their associated contaminants are the most significant source of the important COPCs/COPECs to the river and Newark Bay, and represent an important contaminant source to the New York Harbor Estuary. As such, a remedy which addresses this source will significantly affect the state of the estuary. While there are other sources of COPCs/COPECs to the river, the EMBM shows that they do not have nearly the same importance as the Lower Passaic River sediments, regardless of mechanism. Although arguments can be made that may slide the positions of individual sources within this hierarchy, no arguments can be made that will move the Lower Passaic River sediments from their position as clearly the most important. For this reason, the EMBM stands in support of an early action. Further, the EMBM shows that by isolating the sediments of the Lower Passaic River from the estuary, the related mechanisms at work in the Lower Passaic River will be significantly diminished, and the recovery of the system will be enhanced and expedited.

Table 2.4-8 outlines the major assumptions of the EMBM and provides a short discussion of the evidence supporting each assumption, the strength of the data supporting the assumption, and possible additional analysis. While more data of various kinds would help refine certain aspects of the EMBM, getting more data would not significantly or fundamentally alter its basic conclusions. Given the relative magnitudes of the various source terms, the uncertainties in the conclusions of the EMBM regarding the importance of the sediments are collectively smaller than the scale at which the conclusions that would drive remedial decision-making for the legacy sediments operate. That is, the uncertainties are relatively unimportant because the possible outcomes all lead to the same conclusion, the overriding importance of the legacy sediments to the recovery of the river.

[To be addressed: Further discussion on the uncertainties in the EMBM with respect to the geochemical evaluations conducted in support of the EMBM.]

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
Modeling (M) Assumptions			
M 1 - The EMBM is over-determined, meaning that the number of sources is less than or equal to the number of chemical species. In this analysis, nine chemicals were considered as parameters for the model, compared to the five source terms. Note that these nine parameters overlap with the COPCs listed in Table 2.4-3 but are not inclusive.	The use of the cluster analysis documents the independence among the variables selected. Essentially, each of the major sources has at least one or two contaminants that uniquely identify it, creating unique ratios among the contaminants found in that source. When contaminant ratios are less unique or well defined, the absolute magnitude of contaminant concentrations and the solids load constrain the possible contribution from the source	Strong	Better data on CSOs, SWOs and the tributaries could better refine the contributions from these sources and provide more parameter to further over-determine the system.
M 2 - The source profiles (*i.e.*, the relative proportion of the nine compounds in each source) are linearly independent of each other and any chemical transformations or losses that occur between the source and receptor are not substantive, leaving relative concentrations unchanged. Therefore, only chemicals that aid in differentiating among the sources (*i.e.*, make the sources independent) were selected for the modeling analysis.	The nature of the contaminants identified by the risk assessment and by the geochemical evaluations are persistent, hydrophobic compounds; hence their long histories and continued presence in the Lower Passaic River despite the near complete cessation of their production and release. These hydrophobic compounds are similar enough geochemically that their ratios on suspended matter are only expected to change when mixed with other suspended solids with different contaminant ratios.	Strong	Further collection and analysis of dissolved and suspended matter fractions would provide further support for this assumption.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
Source Term (ST) Assumptions			
ST 1 - The number of significant sources is known and includes the Upper Passaic River (above Dundee Dam), the tributaries, CSO/SWOs, the legacy sediments within the Lower Passaic River, and Newark Bay. Contaminant inputs from atmospheric deposition are assumed to be negligible.	The watershed is sufficiently well known that the surface water sources are all well defined. The tributaries integrate a far greater area than that of the surface of the Lower Passaic itself. The low levels of contaminant concentrations and the small solids contributions from the tributaries indicate that direct atmospheric input to the surface of the Lower Passaic River is negligible.	Strong	Confirm New Jersey Pollution Discharge Elimination System (NJPDES) permits

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
ST 2 - Contaminant inputs from groundwater and NJPDES permitted discharges are assumed to be negligible.	Groundwater and NJPDES permits (other than CSOs and storm water) each contribute about 1 to 1.5 percent of the overall flow in the Lower Passaic River based on baseflow separation and NJPDES permit records (Appendix B of the CSM; Malcolm Pirnie, Inc., 2007a). Groundwater discharge velocity is not sufficient to carry suspended solids and is likely to be focused through more permeable strata such as sands and gravels rather than through contaminant laden sediments. Most of the NJPDES permitted flow is accounted for by the CSO/SWOs and was considered by the EMBM. The NJPDES permits limit the total suspended solids (TSS) and total organic carbon (TOC) that can be discharged to between 20 and 50 mg/L. Records from the largest NJPDES permit holders indicate that TSS is typically much less than 20 mg/L. Given the low solubilities of the constituents used in the EMBM, groundwater additions are not important. With groundwater's inability to move significant suspended solids, the evaluated constituents' low solubilities prevent significant groundwater transport as compared with sediments in the river. Even in the water column, solids-bound contaminants dominate. Groundwater simply cannot transport dissolved constituents in significant quantities to effect the contamination of 100,000 cy of sediment annually. Simply put, groundwater can only contribute dissolved constituents and is only about one percent of the overall flow in the river and most of the NJPDES permit flow was considered by the EMBM flow. The remaining NJPDES permitted flow is at TSS concentrations that are less than the rivers, so are not significant to the EMBM.	Strong	Pore water samples could confirm COPC concentrations. Seepage velocity metering could be done to determine the rate of groundwater discharge in sediment laden areas. Freedom of Information Act review of NJPDES records would be required to determine the precise volumes.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
ST 3 - The nature of the external sources is known, and the available data represents the current average composition of all these sources. The composition of the legacy sediments is well constrained by available data	Beryllium-7 (Be-7)-bearing sediment samples are available for the two main external sources (Upper Passaic River and Newark Bay). These samples provide an integrated sample of contamination on the solids delivered by these sources. Contaminant Assessment and Reduction Project samples provide a sufficient basis to define concentrations in CSO and SWO discharges (12 samples of each, 2-3 samples collected over time from 3 to 4 locations). USEPA's high resolution sediment cores document the history of sediment contamination in the Lower Passaic River and thereby limit the possible range of properties for this source. The mass balance is ultimately robust enough to limit the possible properties of this source and document its overall importance. Tributaries have a limited number of samples but their small solids contribution limits the resulting uncertainty in the EMBM associated with this source.	Robust for Newark Bay. Strong for Upper Passaic, measured SWOs. Reasonable for CSOs and unmeasured SWOs. Reasonable for tributaries.	Additional data from Be-7 bearing sediment samples above Dundee Dam would provide a better estimate of the recent variability of this source.
ST 4 - Newark Bay suspended matter can be characterized by Be-7 bearing sediments from the main channel in the southern end of the bay.	A series of Be-7 bearing samples were obtained from the Newark Bay channel, documenting the nature of suspended solids in the bay. Sensitivity analysis using Be-7 bearing samples from the northern end of Newark Bay did not affect model solution. See ST 9 which discusses Be-7-bearing sediment assumptions.	Strong	Future Newark Bay sediment samples will provide further support.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
ST 5 - The diagnostic ratio of 2,3,7,8-TCDD/Total TCDD of 0.7 to 0.8 can be used to trace the Lower Passaic River 2,3,7,8-TCDD source throughout the Newark Bay complex and over the last 60 years.	Work by Chaky (2003) on Newark Bay has been verified by the 2005 USEPA work in the Passaic as well as by sampling conducted by TSI in 2005 in Newark Bay. Dated sediment cores from both USEPA and TSI document the dioxin ratio over time.	Robust	Dated sediment cores from Newark Bay would provide a more detailed record for that portion of the system.
ST 6 - CSO discharges from the Hackensack can be used to estimate the contaminant concentrations found in Lower Passaic River CSO discharges.	CSO discharges to the Hackensack River would be similar to CSO discharges to the Lower Passaic River, since the drainage areas in both "sewersheds" are characterized by similar levels of industrial, commercial, and residential development.	Reasonable	Additional sampling of the CSOs to the Lower Passaic River would remove or reduce the need to make this assumption. These data could also better estimate the magnitude of this source term, although it is unlikely to become important for most of the COPCs.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
ST 7 - Metals levels in the tributaries are similar to those found in the Upper Passaic.	In general, the tributaries and the Passaic River both drain similar geological settings. In the absence of industrial discharges, their metals levels on suspended solids should be similar. The limited samples from the tributaries did not show unusually high levels of lead or cadmium but the sample set was very small and occasionally noisy since it was determined by the difference between whole water and dissolved fraction measurements. Given that the Dundee Dam sediment core provided a similar value for these metals, the Dundee Dam core value was used when the tributary sample results were poor. This provided a more time averaged number that was a conservative estimate of the actual loading based on the available data. The lead concentration for Saddle River of 160 mg/kg was replaced with the value of 142 mg/kg. Cadmium concentrations for all three tributaries were replaced with 2.2 mg/kg but were not used in the EMBM calculation.	Reasonable	Additional sampling of the tributaries to the Lower Passaic River would remove or reduce the need to make this assumption. These data could also better estimate the magnitude of this source term, although it is unlikely to become important for most of the COPCs.
ST 8 - The factors affecting the contaminant loads are similar for the three tributaries to the Lower Passaic River, suggesting the loads represent an amalgam of urban runoff and small CSOs with little substantive industrial discharge.	The plots show a strong correlation among the contaminant concentration in the three tributary sources, indicating that their contaminant patterns are not independent. Consequently, the three tributaries were combined into a single source to maintain the objective of independence in the model.	Reasonable	Additional sampling of the tributaries to the Lower Passaic River would remove or reduce the need to make this assumption. These data could also better estimate the magnitude of this source term, although it is unlikely to become important for most of the COPCs.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
ST 9 [High Resolution Core (HRC) 1]* - The Be-7 bearing layer represents an amalgam of the water column suspended matter over the past 6 to 12 months, weighted in proportion to solids load. **Note that this assumption and the subset of source term assumptions to follow are strongly linked to the interpretation of high resolution sediment cores, hence their secondary designation.*	Be-7 is a short-lived radionuclide produced in the upper atmosphere by cosmic radiation. The highly particle-reactive nature of the element causes it to adhere to air-borne particles which carry it to the earth's surface. Particles falling on the surface of the river are incorporated in areas of accumulating sediment. Because of its short half-life (54 days), it can only be detected in particles that have been deposited in the last 6 to 12 months. Water column measurements of suspended matter revealed the same diagnostic ratio of 2,3,7,8-TCDD/Total TCDD observed in the sediments, as well as contaminant concentrations per unit mass that agree closely with the surface sediment observations.	Robust	

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
ST 10 (HRC 2) - High resolution sediment core sites have not been subject to vertical mixing beyond 2 to 3 years (*i.e.*, the mixed layer is no more than 2 to 3 years thick)	The identification of an interpretable cesium-137 (Cs-137) profile consistent with the known input function for Cs-137 is direct evidence for the lack of substantive bioturbation or tidally driven vertical mixing. In the presence of these processes, the magnitude of the Cs-137 maximum is greatly diminished and the width of the peak is significantly broadened. Additionally, the ability to identify multiple cores by both USEPA and TSI collection efforts that meet the Cs-137 requirements while reflecting the same depositional histories for a broad range of contaminants provides further support for the existence of these conditions.	Strong	Additional cores along the river's main axis would serve to further refine the history of transport and provide some knowledge of pre-1950s deposition, which was not obtained by the previous efforts.
ST 11 (HRC 3) – The occurrence of DDT predates the release of 2,3,7,8-TCDD contamination by perhaps 10 years.	Work by Bopp *et al*. (1991a, 1991b) suggests this based on both cores and industrial records. Dated sediment cores show the appearance of DDT at or before the appearance of dioxin.	Strong	
ST 12 (HRC 4) - Elevated concentrations of arsenic, chromium, copper, lead, Total PAH, and benzo[a]pyrene occur at depth in dated sediment cores, usually reaching a maximum at the core bottom, indicating that the vertical extent of these contaminants is undefined. Mercury and cadmium also remain above background, at depth.	Based on 11 dated core sites from the TSI 1995 investigation.	Strong	Review the USEPA 2005 high resolution cores for consistency with this observation.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
ST 13 (HRC 5) - Total PCB is found throughout the Lower Passaic River but is among the "shallowest" of contaminants. Aroclor 1248 is the most commonly reported PCB mixture, typically comprising 60 percent or more of the Total PCB burden.	Based on 11 dated core sites from the TSI 1995 investigation as well as 5 dated USEPA cores from 2005.	Robust	Review the USEPA 2005 high resolution cores for consistency with the Aroclor 1248 observation.
ST 14 (HRC 6) - Major historical loads (*circa* 1963) of cadmium, lead, mercury, and Total PCB primarily originated in the Upper Passaic River above the Dundee Dam. A substantial load of copper also originated above the Dundee Dam, but an additional source was present downriver. Smaller sources of contamination, particularly mercury, may also have existed in the Lower Passaic River (RM0 to RM7).	Dated sediment core evidence from Dundee Lake in the Upper Passaic River and Lower Passaic River provide the basis to describe this history	Strong	Additional dated cores above Dundee Dam and from the Lower Passaic River will bolster this conclusion.
ST 15 (HRC 7) – Under more recent conditions (*circa* 1985-1995), the Upper Passaic River remains a major source of cadmium, mercury, and lead and an important source of Total PCB. In addition, evidence suggests that in 1995 at least two sources exist in the Lower Passaic River (one at or below RM1 and one at or above RM7) for arsenic and chromium. Evidence also exists for at least one Lower Passaic River source for cadmium, mercury, and Total PCB.	This assumption is based on observations of surface concentrations in a limited number of Dundee Lake samples from a dated core and on the gradients apparent in the 0-6 inch samples obtained by TSI in 1995. The evidence for the Upper Passaic source of cadmium, mercury, lead and Total PCBs is unequivocal. The evidence for Lower Passaic River sources is less certain since the gradients in surface sediments from 1995 were not observed in Be-7 sediments in 2005.	Strong to reasonable	Additional samples above Dundee Dam and from the Lower Passaic River will bolster this conclusion.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
ST 16 (HRC 8) - Little (less than 1 percent) of the historical 2,3,7,8-TCDD contamination in the Lower Passaic River originated above the Dundee Dam. Current loads of 2,3,7,8-TCDD from above the dam represent only about 2 percent of the total load from the Lower Passaic River.	Dated sediment core evidence from Dundee Lake in the Upper Passaic River and Lower Passaic River provide the basis to describe this history.	Strong	Additional dated cores above Dundee Dam and from the Lower Passaic River will bolster this conclusion.
ST 17 (HRC 9) - A small fraction of the Total DDT load to the Lower Passaic River originated upriver of the Dundee Dam, at least since 1963.	Dated sediment core evidence from Dundee Lake in the Upper Passaic River and Lower Passaic River provide the basis to describe this history. The importance of upriver loads prior to 1963 could not be assessed.	Strong	Additional dated cores above Dundee Dam and from the Lower Passaic River will bolster this conclusion.
ST 18 (HRC 10) – Total PAH contamination appears to be derived primarily from combustion-related processes, probably manufactured gas plants.	This assumption is based on a PAH ratio analysis completed as part of the geochemical evaluation of the site. This analysis showed the PAH ratios to be consistent with those derived from manufactured gas plant operations. The Lower Passaic River has one or more such plants located along its banks and in its watershed. Additionally, cores collected above Dundee Dam show visible evidence of oil contamination at depth below the Cs-137 horizon.	Strong	Additional PAH data from deeper cores could further substantiate this observation.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
System Process (SP) Assumptions			
SP 1 – The model focuses on the movement of solids; therefore, only chemical species that are associated exclusively with solids were evaluated. Dissolved-phase concentrations (and the processes impacting the dissolved-phase concentrations) are assumed to have a negligible effect on the concentration ratios of the chemicals evaluated	The primary risk drivers are contaminants that are strongly particle bound. The high levels of suspended solids in the water column of the Lower Passaic result in dissolved phase inventories that are less than 10 percent for nearly all contaminants examined. Because of the much larger inventory associated with the sediments, the dissolved phase will follow the "lead" of the suspended solids. The FFS is focused on strongly particle-bound contaminants with partitioning coefficient in the 10^5 range and greater. The EMBM was not used in determining which contaminants were selected as COPCs for the early action.	Strong.	Confirm the dissolved phase concentrations with existing measurements and equilibria partitioning. Additional samples would provide further support.
SP 2 - Water residence time is sufficiently short within the Lower Passaic River that *in situ* processes such as gas exchange and oxidation do not substantively affect the water column inventories of the contaminants examined. As a result, the constituents studied mix conservatively. Moreover because of the rapid mixing of solids in the water column, any *in situ* losses affect the blend of the various sources and not one source relative to another.	The relatively short length and shallow bottom of the Lower Passaic River and its connection to Newark Bay result in high rates of tidal exchange, high tidal currents and a large tidal displacement relative to the river's length. Daily tidal exchange alone results in a tidal displacement volume that is more than one-third of the volume of the entire Lower Passaic. Thus the entire Lower Passaic is effectively flushed every two to three days.	Strong The ability to create an over-determined mass balance for the nine contaminants is in itself evidence of this assumption.	Further analysis of existing mooring data could further refine the water residence time estimate.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
SP 3 – The combination of the current channel geometry and the large tidal forcing (a mean 5-foot tide in a channel with a mean depth of 13 feet) and associated tidal velocities yield a very dynamic mixing system for suspended solids. As a result solids are well mixed over long distances prior to deposition, permitting the modeling of the Lower Passaic River as a single well-mixed "box."	The agreement in absolute concentrations and contaminant depositional histories between 5 dated sediment cores spanning 12 miles of the river can only be the result of extensive mixing by tidal action prior to permanent sediment deposition at the sampling sites. Any dateable cores obtained between these cores would yield essentially the same history, as shown by the agreement with the TSI cores obtained 10 years previous to the USEPA effort.	Robust	See above.
SP 4 – The Lower Passaic River has been net depositional since the construction of the channel in the first half of the 20th century. Nonetheless, under current conditions, perhaps 20 to 50 percent of the solids that enter from the Upper Passaic River and tributaries are transported out to Newark Bay.	Core evidence clearly documents thick sequences of contaminated sediments that could only have arisen in the latter half of the 20th century. The volume of contaminated sediment is so extensive that it would have taken many years to accumulate. However, a dioxin mass balance for Newark Bay clearly indicates the impact of dioxin-contaminated sediment from the Passaic.	Robust	Redo Newark Bay solids balance with updated core results and updated Passaic head-of-tide sediment loads.
SP 5 - Sediment deposition rates in the Lower Passaic River (RM0.9 to RM7) have a high degree of spatial variability, varying from about -6 inches per year of erosion to about +8 inches per year of deposition over short distances.	Bathymetric surveys conducted since 1995 clearly document changes in the sediment elevation which are well beyond measurement precision.	Robust	Further study is unlikely to provide better resolution since depositional and erosional areas are not fixed in space. Seasonal studies might help better quantitate the Passaic River's role in Newark Bay contamination.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
SP 6 - Major releases of 2,3,7,8-TCDD with a unique industrially-derived dioxin ratio begin in the 1950s and peak in the 1960s, with the characteristic ratio still present in the most recent sediments.	Consistent observations by Bopp *et al.* (1991a), Chaky (2003), TSI in the 1990s (Lower Passaic River), USEPA in 2005 (Lower Passaic River) and TSI in 2005 (Newark Bay) all show the same depositional history and diagnostic ratio over time.	Robust	Dated sediment cores from Newark Bay would provide a more detailed record for that portion of the system.
SP 7 - Erosional areas may be more concentrated in some areas than others, but can be found throughout the Lower Passaic River.	Surface sediment data at RM3 to RM4.5 suggest that this region may have a number of locations undergoing erosion and exposing older, more contaminated sediments. However, bathymetric surveys also show erosional areas in all reaches and suggest migration of these areas over time.	Strong	Continued period bathymetric surveys of Lower Passaic River will continue to support this observation of erosion and document the movement of erosional areas with time, additional samples will confirm the high concentrations being exposed.
SP 8 - Lower Passaic River solids comprise approximately 10 percent of the total amount of solids accumulating in Newark Bay. More than 80 percent of the 2,3,7,8-TCDD accumulating in Newark Bay must originate from the Lower Passaic River. No other single source delivered more than 10 percent of the load. The Lower Passaic River is responsible for approximately only 20 percent of the total annual mercury load to Newark Bay.	A concurrent mass balance analysis of loads to Newark Bay for solids, 2,3,7,8-TCDD, and Total TCDD resulted in a revised solids mass balance [relative to Lowe *et al*., (2005)] for Newark Bay with Lower Passaic River solids comprising approximately 10 percent of the total amount of solids accumulating in the bay. The estimated current (*circa* 1995) total annual loads of mercury and 2,3,7,8-TCDD to Newark Bay are approximately 400 kilograms per year and 14 grams per year, respectively.	Strong	This mass balance should be updated to reflect more recent data and further refine this estimate.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
SP 9 – The volume of contaminated sediment in the Lower Passaic River (RM0 to RM8) is estimated at 8 to 10 million cy with depths as great as 20 feet. The sediment is estimated to contain roughly 30 kilograms of 2,3,7,8-TCDD, 50 metric tons of mercury, and 9 metric tons of PCBs	The estimates of contaminant volume and contamination depths are based on records of the original channel construction, recent bathymetric surveys and the 1995 TSI core collection effort. While the TSI cores frequently did not completely penetrate the contaminated sediments, the data combined with the physical measurement evidence provides a sufficient basis to estimate the magnitude of this volume.	Strong to reasonable	Additional investigation, including collecting cores that penetrate the entire thickness of contaminated sediments, would be necessary to narrow the volume and contaminant mass estimates.
SP10 - Tidal mixing has been an important factor in the creation of contaminant inventories in the sediment. Essentially the best predictor for the occurrence of a contaminant inventory is the thickness of the sediment deposits, not the proximity to the source.	Sediment inventories of four major contaminants were shown to correlate throughout the river, indicating that their inventories coincide in space despite the fact that their sources are disparate, arising in both the Upper and Lower Passaic. Essentially, when a location has a locally high inventory of any one of these four contaminants, the other contaminants will also be concentrated at that location. Contaminant inventories vary along the length of the Lower Passaic River with maximum values occurring near RM1 to RM2, RM3 to RM4, and RM6 to RM7, coincident with areas of higher deposition.	Strong	Refinement can be accomplished by further sampling but will not significantly change this conclusion.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
SP 11 - Despite the coincidence of the inventories on large special scales, there is also a high degree of local spatial heterogeneity with respect to inventories. This indicates that localized areas of relatively higher concentrations typically described as "hot spots" do not exist in the Lower Passaic River. Instead, "hot" regions of the river typically exist on the scale of a mile or more, nearly bank to bank in lateral extent.	Although various contaminant inventories are coincident in the sediments, adjacent sediment inventories based on cores can vary significantly. Consistent with the observations of tidal mixing, this heterogeneity is likely due to differences in deposition rate, with higher inventories associated with higher deposition rates, and not with higher concentrations. From the tidal mixing observation, it is expected that fine-grained sediments deposited anywhere in the Lower Passaic River in a given year will have similar concentrations. The differences in inventory reflect the thickness of that year's deposit, rather than its concentration or proximity to the original source.	Strong	Refinement can be accomplished by further sampling but will not significantly change this conclusion.
SP 12 - The sediment record of contamination is a direct result of the various loads discharged to the river. The relative proportion of the contaminant mass deposited in the sediments from each source is assumed to be the same as the relative proportion of the total solids-borne mass load derived from each source. That is, if a source is responsible for 10 percent of the total contaminant mass load, that source is assumed to be responsible for 10 percent of the contaminant mass in the surface sediments.	The choice of particle-reactive contaminants for the EMBM analysis, the highly effective tidal mixing of the Lower Passaic River and the short residence time of water in this system permits this assumption since the particles carry the majority of the contaminant mass and there is little time for *in situ* reactions prior to deposition. As a result, contaminant ratios cannot be changed by dilution or other processes. Only by mixing with other solids with differing contaminant ratios are the ratios changed. The degree to which the ratios are modified reflects the linear mixing of the various sources prior to deposition.	Strong	

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
SP 13 - Animal tissue concentrations are strongly linked to the sediments. As such, a decline in surface sediment concentrations will be directly reflected by a proportional decline in animal tissue concentrations.	Numerous refereed articles on the relationship between sediments and animal tissue concentrations. Direct Passaic evidence includes correlations between fish tissue and sediment concentrations for a number of contaminants. Additionally, measurements of 2,3,7,8-TCDD in blue crab also revealed the diagnostic ratio of 2,3,7,8-TCDD/Total TCDD observed in the sediments.	Strong	Further study of animals and sediments can further refine this but are unlikely to change the basic premise.
Future Conditions (FC) Assumptions			
FC 1 - The observed concentration trends for the COPCs will continue to decrease at a rate consistent with the half life values provided in Table 7-4 of the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b) from 2005 to the implementation of the remedy in 2018. For the natural recovery scenario, the observed rate of decline will continue for the entire period considered.	The site-specific characterization provided by the high resolution cores, provides a basis for evaluating natural recovery. The observed rate of decline in concentration for several chemicals in these cores reflect the processes that are on-going in the system, and these processes should continue to act on the system if no active remediation is undertaken. Forecasting changes in the loading from external sources will require a complete study of their respective watersheds. Therefore the changes that have occurred over the past 25 years depicted in the high resolution cores reflect the in-river natural processes as well as the response to any changes in external sources.	Robust – High resolution cores from disparate locations in the Lower Passaic River have similar trends for the COPCs analyzed, showing that the processes at work in the river are relatively similar regardless of location. Furthermore, the high resolution cores provide a basis to determine these half-lives based on the depositional record of the past 25 years, a period of sufficient length to provide a high level of confidence in the estimated future rate of decline.	Additional high resolution cores could refine the half-life values and cores collected in the contributing sources (*e.g.,* Dundee Dam and Saddle River) could refine the input functions, however, given the agreement seen in the cores that have been studied, additional information will not significantly change projections, although it may identify areas where additional reductions can be pursued.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
FC 2 – Remedial efforts that remove or isolate sediments between RM0 to RM8 will control approximately 90 percent of the fine-grained sediment resuspension process and will substantively reduce surface sediment concentrations by 2048.	Contaminants generally partition to fine-grained sediments and these sediments have the potential to be resuspended and transported in the water column. Caps are designed to: physically isolate the contaminated sediment from the aquatic environment, prevent erosion and resuspension of contaminated sediment, and also to provide chemical isolation. Therefore, effective placement of a well designed cap should control the resuspension source term.	Robust – Designed caps are accepted tools for control of sediment resuspension .	Since this is standard engineering, no additional data is needed to support this assertion, however a design phase including a design investigation would be necessary to design an appropriate cap.
FC 3 – The effectiveness of the Area of Focus remedy is linked to the percentage of the fine-grained sediment area addressed by the remedy.	The reservoir of active contaminated sediments is largely confined to the areas of fine grained sediments. Areas of coarser sediments are not readily reworked by tidal energies and so do not contribute substantive contaminant mass to the active sediment layer present in the fine grained areas of the Lower Passaic River. The Area of Focus (RM0 to RM8) represents about 90 percent of the fine grained area contained in the Lower Passaic River. Thus addressing this area should reduce the legacy sediment contribution to the surface sediments of the Lower Passaic River by at least this amount. This assumes that the fine-grained sediments of the areas upstream of RM8 act in the same manner as those downstream. Given the thinner sediment inventories and lack of channel infilling upstream of RM 98, this is a conservative assumption with respect to the impact of the remedy. Note that under this assumption, the result is insensitive to the exact resuspension process.	Reasonable	See FC 2.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
FC 4 – For those COPCs that are not directly examined in the mass balance model, the fraction of the non-modeled COPC load that is associated with resuspension (and thus can be remediated) can be estimated from the solids balance and the concentrations of the non-modeled COPC associated with the various source terms.	The solids balance developed for the EMBM can be used for any contaminant that is strongly particle reactive and satisfies the other assumptions of the mass balance. Many compounds mimic the behaviors and mass balance loads of the compounds studied. The fact that they were not selected does not mean that it is not possible to model them. In most cases it simply means that they were too similar to one of the nine selected COPCs and thus did not represent an independent variable.	Strong	Not applicable

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
FC 5 - Following remediation, surface sediment concentrations will continue to decline with the same half-life values provided in Table 7-4 of the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b) from 2018 to 2048. No improvement in the half-life is assumed as a result of the remediation.	Because the compounds being evaluated are recalcitrant and not significantly degraded by biogeochemical processes, they are conservative tracers in the environment. As such the reduction in concentration over time observed in the surface sediments is a function of the external solids delivery and the physical mixing/resuspension processes, especially dilution by less contaminated sediments. Unless the quantity of solids delivered from the external sources changes significantly, the process will continue as observed. It is assumed that the control of the contributions from Lower Passaic River legacy sediments will not substantively affect the mixing of solids from the external sources. Moreover, for those compounds primarily driven by the legacy sediments (*e.g.*, 2,3,7,8-TCDD), the rate of concentration decline is governed strictly by the solids mixing/delivery process and the rate of change in the concentrations on external solids is of little importance. For those compounds with significant external loads (*e.g.*, PAHs), the observed rate of decline in the source concentration is likely reflected in the observed sediment core trend since so much of the mass is derived from this source. The greatest level of uncertainty arises for those compounds with multiple sources. Even here, however, the post-remediation rate of decline is unlikely to be very different from the observed rate of decline, since the remediation itself will only affect a relatively small fraction of the annual load.	Strong/conservative - It is acknowledged that significant changes in the Lower Passaic River's flow due to deepening will influence the sedimentation rate in the Lower Passaic River. It is likely that additional solids will be added from Newark Bay and the Kills. This is evidenced by the declining sedimentation rates seen in the high resolution core that are interpreted to be the result of the infilling of former dredged channels. The historical sedimentation rates (pre-1963) require significant input from the estuary end member. For all of the contaminants modeled, Newark Bay represents a diluting end member so any increase in its solids contribution will likely increase the post-remediation rate of decline.	Study of pre-1963 sedimentation rates could be related to inputs from the estuary end member to estimate the additional sediments derived. However, using the conservative assumption that the rates will not be affected by remediation provides a minimum estimate of the degree of improvement through remediation. Because the hydrodynamics do not significantly change under the No Action alternative, comparison of remedial forecasts to natural recovery based on the projected half-lives should be conservative in that it should provide a minimum estimate of the degree of improvement. (Note that input of sediments from the estuary end member is likely to slowly decrease as the river bottom elevation reaches a steady state condition. This should increase the relative contributions of resuspension and head-of-tide solids in the surficial sediments, and the rate of decline under natural recovery should decrease with time.)

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
FC 6 – The LWA and 1990s scenarios represent two ends of the possible range of conditions for sediment resuspension, with the true answer lying in between (*i.e.*, some combination of erosional area contribution with vertical sediment mixing by tidal energy). The LWA scenario is probably closer to the true condition based on evidence for the existence of erosional areas throughout the Lower Passaic River. The simple 1990s scenario is deemed less likely due to the amount of vertical mixing required. Notably, either scenario will respond in approximately the same way, based on FC 3.	Besides providing one of the best fits to the data, the LWA scenario is supported by other observation, such as the occurrence and migration of erosional areas. The 1990 scenario requires the blending of the annual 1 to 1.5 inches of net deposition (which arises from external sources only) with sufficient 1990 material so as to create the observed concentrations in Be-7 bearing sediments. Under this scenario the surface layer is comprised of more than 95 percent 1990s material. Thus the independent estimate of the annual net rate of deposition (1 to 1.5 inches per year) would require a mixed layer at least 20 times thicker(*i.e.*, 20 to 30 inches). A similar thickness can be obtained based on the 2,3,7,8-TCDD half life, the annual rate of net deposition and the consideration that the external sources contain little or no 2,3,7,8-TCDD. The 30 inch mixed layer estimate in the EMBM is based on this approach, using the 1.5 inch deposition rate.	Reasonable	While further study could certainly refine the source term issue, any of the scenarios considered show the legacy sediments to be the major problem with respect to nearly all COPCs, regardless of the actual legacy sediment to external sources solids ratio.

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
FC 7 – The post-remediation contaminant concentrations in surface sediment assume no mixing between deposited sediment and cap material. The formula derived in Attachment H of the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b) is based in this assumption.	This assumption is conservative in that it provides a minimum estimate of the reduction of future sediment concentrations and associated risk. It is important that the benefit of the remedy from a risk standpoint is not overstated. The exposure concentrations obtained by this expression are upper bound values and hence provide conservative estimates of the benefits in terms of risk. In reality, mixing of newly deposited sediment and cap material are likely to occur and actual initial concentrations will be lower than predicted in the EMBM. The concentration should subsequently increase for a short period, followed by a long term decline wherein concentrations should still be lower than values assumed in the EMBM analysis. Therefore, recovery from a risk standpoint is expected to be better than estimated in the EMBM.	Strong	N/A

Table 2.4-8: Assumptions and Supporting Evidence Used in the Development of the EMBM

Major Assumptions	Rationale and Supporting Evidence	Strength	Possible Additional Data Support
FC 8 – The impact of the reduced remedial area can be estimated by the amount of erosional area contained within the Primary Erosional Zone/Primary Inventory Zone.	Unlike assumption FC 3, the effectiveness of the Primary Erosional Zone/Primary Inventory Zone remedial scenario is based on the amount of erosional area addressed, and not simply the amount of dine-grained area addressed. This additional "credit" is based on the LWA scenario, which assumes that the legacy sediment is released from a small fraction of the surface area of the fine grained sediment. The 1990s-based solution would yield a smaller impact since it would be based on total area addressed. The Primary Erosional Zone/Primary Inventory Zone was identified based on the higher concentration of erosional areas in this region of the river. The Primary Erosional Zone/Primary Inventory Zone also contains some of the highest inventory areas but the overall fraction of the surface area addressed is still less than the fraction of the erosional area addressed.	Reasonable - This approach provides an upper bound in what might be achieved by a lesser remedy.	Additional study is unlikely to de-link the assumption of sediment surface area and legacy sediment contribution. In particular, the evidence weighs strongly against "surgically" addressing small areas of the Lower Passaic River sediments. The extensive level of tidal mixing, the intermingling of erosional and depositional areas, and the movement of erosional activity suggested by the many bathymetric surveys indicate that it is not possible to find areas that yield a disproportionate amount of legacy sediment and can be sufficiently controlled so as to avoid the need for a larger remedy. Closer study of the bathymetric surveys and continued regular bathymetric surveying should be done to better define the movement of erosional areas suggested by the analysis done to date.

2.4.7 Areas of Archaeological or Historical Importance

Formal cultural resource surveys have not yet been conducted for the Lower Passaic River. However, a geophysical survey of the Lower Passaic River was conducted by Aqua Survey, Inc. (Aqua Survey, Inc., 2006) along the majority of the 17-mile Study Area. One of the objectives of the survey was to provide archaeological data essential for complying with the National Historic Preservation Act of 1966 (as amended through 1992) and the Abandoned Shipwreck Act of 1987. Technologies employed in the geophysical survey included sidescan sonar, sub-bottom profiler, fathometer, magnetometer, real-time kinematic differential global positioning, shallow push coring, and deep vibracoring.

The sidescan sonar survey indicated the presence of one potentially historically significant submerged cultural resource located at approximately RM11.5. The item is a probable shipwreck and was identified as a sonar target with an associated magnetic anomaly. Note that this wreck is located outside of the Area of Focus for the Source Control Early Action.

Stage 1, and likely Stage 2, cultural resource surveys of the river bed will be conducted as part of the pre-design investigation. In addition to evaluation of the submerged river bed, mud flat and river bank areas that were not included in the geophysical survey due to shallow water depths should be assessed for the presence of historically significant artifacts and evidence of colonial/pre-industrial habitation and use. Based on the results of an initial survey in these areas, mud flats and the river banks may require further analysis in a Stage 2 investigation.

2.4.8 Summary of Conceptual Site Model

In summary, although the Lower Passaic River is a partially stratified estuary, the tidal excursion is sufficiently energetic that the water column remains well-mixed with respect to suspended solids. The tidal portions of the river have been subject to increased sedimentation rates resulting from historical dredging followed by decades of minimal maintenance dredging. The period of minimal maintenance dredging coincided with a period of significant discharge of industrial and municipal waste to the river. Subsequent re-filling of dredged channels due to the reduced maintenance during the period of industrial discharges and the combination of relatively well-mixed suspended matter and high deposition rates yielded thick sequences of contaminated sediment. For this reason, local variations in sediment contaminant inventory are primarily attributed to variations in depositional rates, and not proximity to local sources; however, the resolution of available data sets is not sufficient to eliminate the possibility of very localized areas of high contaminant concentrations in the immediate vicinity of point sources.

Surface concentrations in the Lower Passaic River are relatively homogeneous over long distances, with the range typically less than a factor of 3 along 12 miles or more of the river. The relative homogeneity of contaminant concentrations in the surface sediments over these large distances is a function of the energetic tidal mixing. Locally, however, spatial heterogeneity exists among sediment core data, indicating the presence of "hot zones" of the river on the scale of a mile or more. Surface concentrations of many contaminants (*e.g*., 2,3,7,8-TCDD) are maintained at high levels by erosion and resuspension of older, more contaminated sediments within the Lower Passaic River. Conversely, the concentrations of several important chemicals (*e.g.*, PAH) receive a significant input from external sources above the head-of-tide. Concentrations of some contaminants, such as PCB, are maintained by both head-of-tide influences and resuspension of legacy sediments. The continued elevated surface concentrations, resuspension of historic inventory, and tidal exchanges with down-stream water bodies provide a continuing source of contaminants to Newark Bay and the remaining New York Harbor Estuary.

2.5 CURRENT AND POTENTIAL FUTURE SITE AND RESOURCE USES

2.5.1 Land Use

2.5.1.1 Current On-Site Land Use

The current land use characteristics of the banks of the Lower Passaic River are described in a Navigation Analysis (Appendix F of the FFS; Malcolm Pirnie, Inc., 2007b) prepared by the USACE in support of the FFS. The left bank (ascending) of the river between RM0.0 and RM4.6 (Newark, New Jersey) can best be characterized as fully industrially developed. The right bank (ascending) in this reach of the river is located in Harrison, New Jersey and is occupied by the railroad tracks of the PATH system and by an intermodal container-handling facility. Transitional land use areas are located on both banks of the river upstream of the Jackson Street Bridge (RM4.6). The left bank in this area of the river is dominated by McCarter Highway (New Jersey Route 21). The right bank in this area of the river is being redeveloped for a combination of residential and recreational uses. Redevelopment transition can be seen at Clay Street in Newark on the left bank, where a complex of storage tanks appears to be in the process of being dismantled. McCarter Highway (New Jersey Route 21) continues north along the left bank of the river (RM4.6 – RM15.4) to Dundee Dam. The right bank of this segment of the river is characterized as recreational parkland (containing at least one small public marina and a few private docking facilities for recreational craft) as well as some residential and light commercial land use areas. A recent examination of the river from adjacent roads revealed no storage tanks or facilities for commercial cargo vessels upstream of the tanks at Clay Street.

Current land use immediately adjacent to the Lower Passaic River, including the area located within the 100-year and 500-year floodplains, is predominantly urban, with some scattered areas of forested land and wetlands (Figure 2.5-1).

2.5.1.2 Current Adjacent/Surrounding Land Use

The current land use characteristics of New Jersey counties encompassing the Study Area are described below (Malcolm Pirnie, Inc., 2006a):

- Bergen County [RM8.8 to Dundee Dam, right bank (ascending)]: Land use is 40 percent residential with 14 percent public and quasi-public open space and 12 percent undeveloped property. Commercial property accounts for only 3 percent of the total land use. Bergen County land use applies to the following communities in the Study Area: East Rutherford, Garfield, Lyndhurst, North Arlington, Rutherford, and Wallington. All of these communities are located upriver of the 8-mile Area of Focus.

- Passaic County [RM11.5 to Dundee Dam, left bank (ascending)]: Land use is a combination of residential, commercial, and industrial properties. The communities of Passaic and Paterson are mixed-use urban areas with high population density. Passaic County land use applies to the communities of Clifton and Passaic. Both of these communities are located upriver of the Area of Focus.

- Hudson County [RM0 to RM8.8, right bank (ascending)]: Land use is evenly mixed between residential, industrial, vacant property, and streets/right-of-way. Water occupies 9,840 acres or approximately one-fourth of the total area of the county. Hudson County land use applies to the communities of Harrison, Jersey City, Kearny, and East Newark. All of these communities abut the river in the Area of Focus.

- Essex County [RM0 to RM11.5, left bank (ascending)]: Land use is highly industrialized, especially in the eastern part of the county abutting the river. Several colleges and universities are also located in the county. Essex County land use applies to the communities of Belleville, Newark, and Nutley. Of these, only Newark is located along the Area of Focus; the others are farther upriver.

2.5.1.3 Reasonably Anticipated Future Land Uses

Reasonably anticipated future land uses for land located immediately adjacent to the Lower Passaic River are described in Section 2.5.2.3 "Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses."

2.5.2 Surface Water Use: Navigation Requirements

The Lower Passaic River contains a federally authorized navigation channel (the dimensions of which are listed in Section 2.5.2.1 "Current Federally Authorized and Constructed Navigation Channel" below). The most recent dredging of the river occurred in 1983, when approximately 540,000 cy of sediment were removed from the lower portion of the river near Newark (Ianuzzi, *et al.*, 2002). Since that time, sediment deposition in the navigation channel has reduced the available draft to less than its authorized depth.

According to *Land Use in the CERCLA Remedy Selection Process* (USEPA, 1995b), remedial alternatives developed during the RI/FS should reflect reasonably anticipated future land use(s). On the shores of the Lower Passaic River, land use and navigation use (and thus navigation channel depth) are very often linked. In order to evaluate the channel dimensions necessary to accommodate current navigation usage, USACE-New York District conducted a survey of commercial stakeholders along the Lower Passaic River (Appendix F of the FFS; Malcolm Pirnie, Inc., 2007b). In order to evaluate the channel dimensions necessary to accommodate reasonably anticipated future usage of the river, the State of New Jersey conducted surveys of municipalities and other local organizations along the Lower Passaic River (Appendix F of the FFS; Malcolm Pirnie, Inc., 2007b). The results of these surveys are described below in Section 2.5.2.2

"Navigational Channel Dimensions to Accommodate Current Surface Water Uses" and Section 2.5.2.3 "Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses".

2.5.2.1 Current Federally Authorized and Constructed Navigation Channel

The current federally authorized and constructed channel depths of the commercially navigable portion of the Lower Passaic River are as follows (Malcolm Pirnie, Inc., 2007b):

- RM0 to RM2.5: The federally authorized and constructed channel depth is 30 feet relative to mean low water (MLW). A bridge abutment at RM1.2 limits channel width to 145 feet. The Point-No-Point Swing Bridge at RM2.5 limits channel width to 103 feet and limits vertical clearance to 16 feet at high water. Fixed span bridges (*i.e.*, bridges that do not open) in this portion of the river include the Conrail Bridge at RM0.75, the United States Route 1 (Pulaski Skyway) Bridge at RM1.8, and the New Jersey Turnpike Bridge at RM2.5.

- RM2.5 to RM4.6: The federally authorized and constructed channel depth is 20 feet MLW. There are no fixed span bridges in this portion of the river.

- RM4.6 to RM7.1: The federally authorized channel depth is 20 feet MLW; however, the channel was only constructed to 16 feet MLW. There are no fixed span bridges in this portion of the river.

- RM7.1 to RM8.1: The federally authorized and constructed channel depth is 16 feet MLW. There are no fixed span bridges in this portion of the river.

- RM8.1 to RM15.4: The federally authorized and constructed channel depth is 10 feet MLW. Fixed span bridges in this portion of the river include the Union

Avenue Bridge at RM13, the Main Street Bridge at RM13.9, the Second Street Bridge at RM14.5, and the 8th Street Bridge at RM 15.

Since the 1940s, there has been little maintenance dredging above RM2. Consequently, the channel has extensively filled back in, particularly between RM2 and RM8. (Refer to Table 2.5-1 for the existing depths of the navigation channel.)

2.5.2.2 Navigational Channel Dimensions to Accommodate Current Surface Water Uses

As part of their navigational analysis, the USACE conducted an evaluation of waterborne commerce conducted between 1980 and 2004 in the Lower Passaic River (Appendix F of the FFS; Malcolm Pirnie, Inc., 2007b). The analysis concluded that over 90 percent of cargo (mostly consisting of petroleum and petroleum products) transported along the river is carried in vessels loaded to less than 13 feet draft, with the exception of 13 records of vessels having 26-foot drafts in 2004. Because the bulk of these shipments occurred between RM0 and RM1.2 where the authorized and constructed depth is 30 feet, the analysis concluded that commercial navigation on the Lower Passaic River is most likely currently constrained by width rather than by depth. The width constraint is due to requirements associated with safe navigation: channel width should be at least five times the beam of the vessel for two-way traffic, and at least three times the beam of the vessel for one-way traffic, with beam defined as the width of a vessel at its widest point, usually mid-ship (USACE Navigational Analysis, Appendix F of the FFS; Malcolm Pirnie, Inc., 2007b).

Based on USACE data, the dimensions of a navigation channel within the lower eight miles of the Lower Passaic River that would accommodate the current usage are as follows:

- RM0 to RM1.2: The authorized depth should be maintained at 30 feet MLW based on United States Waterborne Commerce data that indicate 13 barges requiring 26-foot drafts were recorded in 2004.

- RM1.2 to RM2.5: The authorized depth should be a minimum of 16 feet MLW based on the 5.5-foot tidal range in the lower 2.5 miles of the Passaic River. If the constructed depth falls below this threshold, maintaining safe passage will impose operational limitations to the timing of commerce, requiring shipments to coincide with high tide.

2.5.2.3 Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses

Channel depths to accommodate future usage were considered by the State of New Jersey and were based on future use surveys for municipalities, an evaluation of market and land use scenarios for the Passaic River region, statewide economic and revitalization programs, as well as the USACE Navigation Analysis (Appendix F of the FFS; Malcolm Pirnie, Inc., 2007b). The State's recommendations for a minimum depth requirement in each of the river reaches for future navigation are based on the three key pieces of information described below. These minimum depths would require maintenance in the future to preserve the uses stated.

Municipality Surveys for Future Use and Master Plans: Over 70 surveys were mailed to representatives (Mayors, Assemblymen, Senators, Congressmen) involved in planning for approximately 17 municipalities with the 17-mile Study Area. A total of 13 surveys were returned covering areas within Clifton, Rutherford, Nutley, East Rutherford, Belleville, Bloomfield, Kearny, East Newark, Harrison, Bayonne, and Elizabeth. In addition to the surveys, master plans from Newark, Harrison, Kearny, and Belleville were reviewed to identify potential future redevelopment initiatives. All surveys will be utilized for the overall FS and restoration planning for the entire 17-mile Study Area.

The surveys and master plans outline current and proposed land use patterns which are related to the overall depth required for such designated uses. The survey results indicate that the communities in the upper 9 miles of the Study Area want to enhance public access, preserve open space, and improve recreational uses (*e.g.*, boating, fishing, ecotourism, parks/fields) along the river. In addition, a number of non-profit organizations are working to improve waterfront access (*e.g.*, locations, adequate depths), provide facilities (*e.g.*, marinas, docks), and spearhead recreational regional events. The Lower Passaic and Saddle River Alliance has also proposed a Water Kayak and Canoe Trail from Pompton River (RM32) to the confluence with Newark Bay and up the Hackensack River. Future proposed use planning efforts are summarized in Figure 2.5-2.

USACE-New York District Lower Passaic River Navigation Analysis: The USACE conducted an analysis of past, current, and potential use of commercial entities located on the Passaic River. This study did not attempt to predict future use by the commercial facilities. The results of the USACE analysis and the USACE's recommended minimum channel depths are discussed in Section 2.5.2.2 "Navigational Channel Dimensions to Accommodate Current Surface Water Uses."

Additional Considerations for the State of New Jersey: The navigational recommendations of the State of New Jersey support the goals and objectives for many statewide programs, including: Brownfield Development, Portfields Initiatives, Smart Growth Initiatives, Comprehensive Statewide Freight Planning, the Long Range Transportation Plan, Transportation Choices 2030, State Development and Redevelopment Plan, and the Liberty Corridor Initiative. These programs are important considerations for the State of New Jersey with respect to future economic revitalization and development of the region, which could be constrained if the future authorized depth of the channel were insufficient to support the associated navigational requirements.

The area within Newark's Industrial Zone adjacent to and downstream of RM3.6 is considered a prime location by the State of New Jersey to support mixed-use economic growth and revitalization. The area within this zone has been designated as the Lister

Avenue Brownfield Development Area (BDA) and slated for remediation and reuse. Specifically, the area between RM2.5 and RM3.6 (Blanchard Street/Fairmont Chemical Redevelopment Area) has been identified as a potential site in the Portfields Program and may be used to support Port operations through the placement of warehouse distribution operations. Other areas within the BDA (*e.g.*, Sherwin Williams, the Diamond Alkali Superfund Site, Hilton Davis) are in earlier stages of planning with uncertainties associated with their specific redevelopment. Based on these uncertainties, the significant private investment in Brownfield redevelopment, and the State's alignment of programs encouraging Brownfield redevelopment, the State desires to preserve future growth potential for this area to the maximum extent possible. Several divisions within NJDOT (Statewide Planning, Freight Planning and Intermodal Coordination, Office of Maritime Resources and Project Planning and Development) have determined that the minimum depth recommendations presented in the NJDOT memorandum support the goals and objectives of several statewide programs.

<u>NJDOT Minimum Depth Recommendations</u>: The NJDOT's recommendations for minimum depth requirements in the lower eight miles of the Passaic River (*i.e.*, the Area of Focus) are summarized in Table 2.5-1.

Table 2.5-1: Summary of Current and Recommended Navigational Depths (Appendix F of the FFS; Malcolm Pirnie, Inc., 2007b)

Reach (RM)	Authorized Depth (feet)	Constructed Depth (feet)	Existing Average Depth and Range (feet)	Minimum Depth for Anticipated Future Use (feet)	Comments
0.0-1.2	30	30	Avg: 17.2 Range: 9.5-20.9	30	Maintain existing and future industrial use
1.2-2.5	30	30	Avg: 19.7 Range: 14.8-24.7	16	Preserve future potential industrial uses, brownfields, portfields
2.5-3.6	20	20	Avg: 15.2 Range: 13.0-18.4	16	Preserve future potential industrial uses, brownfields, portfields

Reach (RM)	Authorized Depth (feet)	Constructed Depth (feet)	Existing Average Depth and Range (feet)	Minimum Depth for Anticipated Future Use (feet)	Comments
3.6-4.6	20	20	Avg: 16.4 Range: 11.9-22.1	10	Future recreational and commercial services (*e.g.*, water taxis/ferries)
4.6-8.0	20 (RM4.6-RM7); 16 (RM7-RM8)	16	Avg: 15.7 Range: 5.1-21.9	10	Future recreational and commercial services (*e.g.*, water taxis/ferries)

- RM0.0 – RM2.5: The USACE has determined that current navigational use of the river could be accommodated by an authorized depth of 16 feet (vessels drafting 13 feet) within this reach. Waterborne Commerce of the United States data and current dredging permits indicate use by vessels requiring 26 feet. Based on the recent polling of existing users and examination of current permitted berth dredging, it appears that there is a need for commercial drafts of at least 26 feet today, specifically near the confluence of Newark Bay. Since current users of the river are located in the lower 1.2 miles of the river, the depth requirements for this reach could be divided into two segments:

    - RM0.0 - RM1.2: Facilities that are currently using the river justify maintaining the current authorized depth of 30 feet. The State of New Jersey recommends maintaining the existing authorized depth of 30 feet in this segment.

    - RM1.2 - RM2.5: The depth is proposed to be not less than 16 feet based on future industrial users, brownfields, and portfields sites. Additional deliberation among the State of New Jersey and the cities of Newark and Kearny is planned to finalize the State's depth recommendation for this upper reach.

- RM2.5 – RM3.6: Although Newark's industrial zone above RM2.5 does not currently utilize the river for waterborne transportation purposes, the future plans for this segment may result in complete redevelopment of the area. The minimum depth requirement will be determined by future land use patterns following upland remediation. The State's recommendations consider the possibility of navigational use of the river for the Lister Avenue BDA, consistent with the Liberty Corridor Initiative, or for a use not yet identified. Therefore, the State has recommended a minimum depth of 16 feet in this segment to preserve the potential for future navigational use and economic revitalization of the region.

- RM3.6 – RM4.6: The State has recommended a minimum depth of 10 feet upstream of Newark's industrial zone and downstream of the Jackson Street Bridge. This depth is believed adequate to accommodate planned recreational and commercial services (*e.g.*, water taxis/ferries proposed at RM4.8) in the river as discerned from master plans and municipality surveys.

- RM4.6 – RM8.0: A primary goal of the Lower Passaic River Restoration Project is to improve public access and enhance recreational use of the river. The State's recommendations for river depths between Jackson Street and the Amtrak Bridge consider proposed water taxis/ferries within the river stretch. Future recreational uses and the possibility of commercial services (*e.g.*, water taxis/ferries) are considered for reaches upstream of the Amtrak Bridge. Most recreational vessels less than 30 feet in length have drafts of less than 3 feet; a depth of 5 feet would accommodate nearly all recreational vessels on the Passaic River. A minimum of 7 feet would accommodate all reasonably anticipated recreational uses. If commercial services considered a route upstream of the Amtrak Bridge, a depth of 10 feet would accommodate this potential need. It should be noted that limited bridge openings are a constraint for optimizing recreational use in the upstream reaches of the river.

2.6 SUMMARY OF SITE RISKS

2.6.1 Human Health Risk Assessment Summary

The results of the HHRA are presented in detail in the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b). Cancer risks and non-cancer health hazards were estimated for current and future exposures, assuming RMEs and CTEs to assist in the decision-making process, consistent with the NCP (USEPA, 1990). The evaluation examined chemicals, receptors, and exposure pathways most likely to pose the greatest risk for the entire 17-mile Study Area in the near future. Although it may provide the basis for evaluating the value of an early remedial action, it is not intended to be a complete baseline risk assessment that includes an assessment of risks for all chemicals, receptors, and exposure pathways.

2.6.1.1 Risk Assessment Conceptual Site Model

A human health CSM of the Passaic River site is presented as Figure A-1 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary." The COPCs in the sediment include PCBs, dioxins, pesticides, DDD, DDE, DDT, dieldrin, chlordane, and methyl mercury. The COPCs are a continuing source of contamination to the water column and biota through aquatic and benthic food chains.

For the purposes of this HHRA only those chemicals, receptors, and exposure pathways most likely to pose the greatest risk were considered (refer to Table A-1 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary"). For human health, COPCs evaluated in the FFS (Malcolm Pirnie, Inc., 2007b) represent those compounds that are considered to be most bioaccumulative, most persistent in the environment, and relatively toxic to human and ecological receptors. In addition, these COPCs represent the contaminants that have triggered states to issue fish and shellfish consumption advisories or bans (USEPA, 2000; USEPA, 2005a). USEPA (2005a) reports that advisories have been issued in the United States for 36 chemical contaminants; however, 98 percent of these advisories in effect in 2004 involved five bioaccumulative chemicals: mercury, PCBs, chlordane, dioxins, and DDT.

2.6.1.2 Types and Characteristics of Contaminants of Potential Concern

Summaries of the toxicity associated with the COPCs evaluated in the HHRA are provided below, and the toxicity values used in the calculations of non-cancer health hazards and cancer risks are provided in Table A-2 and Table A-3, respectively, in Appendix A "Supporting Tables for Human Health Risk Assessment Summary." Except where noted, the toxicity values were obtained from the Integrated Risk Information System (IRIS), USEPA's consensus toxicity database. This approach is consistent with the hierarchy of toxicity values identified in the USEPA OSWER Directive 9285.7-53 (USEPA, 2003a).

<u>Dioxins</u>: Dioxin toxicity varies greatly among different congeners and is dependent on a number of factors. Dioxin is classified by USEPA as a Group B2 carcinogen (a probable human carcinogen) based on animal studies and human epidemiological evidence. The most common health effects in people exposed to large amounts of dioxin are chloracne and skin rashes, skin discoloration, and possibly mild liver damage. The cancer toxicity value for dioxin [150,000 milligrams per kilogram per day (mg/kg-day)] from the Health Effects Assessment Summary Tables was used in the calculation of risk. This value was selected since USEPA is currently re-assessing the toxicity of dioxins and related compounds and addressing comments from the 2006 National Academy of Sciences evaluation of USEPA's 2003 dioxin re-assessment. In July 2006, the World Health Organization (WHO) released its re-evaluation of human and mammalian TEFs for dioxins and dioxin-like compounds performed in 2005, and these values were incorporated into the assessment (Van den Berg *et al.*, 2006).

PCBs: PCB toxicity varies greatly among different congeners and is dependent on a number of factors. The assessment evaluated both the dioxin-like (*i.e.*, structurally similar to dibenzo-p-dioxins) and non-dioxin like PCBs (USEPA, 1996). Responses to PCB exposure in animals include wasting syndrome, hepatotoxicity, immunotoxicity, neurotoxicity, reproductive and developmental effects, gastrointestinal effects, respiratory effects, dermal toxicity, and carcinogenic effects. Some of these effects may be manifested through endocrine disruption, and this is an area of continuing research by several federal agencies, including USEPA. USEPA classifies PCBs as a probable human carcinogen (Group B2), based on several studies in animals showing liver tumors with a number of different PCB mixtures which are believed to span the range of congeners found in environmental mixtures (USEPA, 1996). Health effects of PCBs are identified in several USEPA and Agency for Toxic Substance and Disease Registry (ATSDR) documents (ATSDR, 2000; USEPA, 1996). There are several ongoing national and international studies assessing the non-cancer health effects of PCBs in children of mothers who consumed PCB-contaminated fish who are exposed *in utero* and other children exposed perinatally to PCBs from other food sources (*e.g.*, Patandin *et al.*, 1999; Lanting, 1999). Significant associations between perinatal exposure to PCBs and dioxins and adverse effects on growth, immunologic parameters, and neurodevelopment and behavior were observed. The IRIS toxicity values for cancer [based on an oral cancer slope factor of 2 mg/kg-day and an oral reference dose (RfD) for Aroclor 1254] were used in the assessment of the non-cancer health effects.

Mercury: Mercury exists in a number of forms (*i.e.*, elemental and methylated). For this assessment, the IRIS RfD for methylmercury was used in the assessment. Methylmercury is a highly toxic substance, and the most extensive data are available on neurotoxicity, particularly in developing organisms. The nervous system is considered to be the most sensitive target organ and was the basis for the derivation of the RfD.

Pesticides: DDT, dieldrin, and chlordane are associated with liver toxicity and are all classified as Group B2 carcinogens. DDT is also a possible liver tumor promoter in rats.

Chlordane is extremely lipid soluble, and lipid partitioning of chlordane and its metabolites have been documented in both in humans and animals. Recent epidemiological findings indicate that neurotoxicity may be a relevant human toxicological endpoint as a consequence of chronic as well as acute chlordane exposure.

2.6.1.3 Concentrations of COPCs in Each Medium

Estimates of chemical concentrations at points of potential exposure were used in calculating the chemical intakes by potentially exposed receptors. The exposure point concentrations (EPC) represent "a reasonable estimate of the concentration likely to be contacted over time" (USEPA, 1989). The 95 percent upper confidence limit (UCL) on the average was used (consistent with guidance) because of the uncertainty associated with estimating the true average concentration at a site. Calculation of the EPCs followed USEPA guidance (USEPA, 2002a), using distribution shift tests to determine the underlying population distribution. Specifically, the ProUCL software package (Version 3.0; USEPA, 2004) was used to determine the underlying distributions and to determine the most applicable EPC for a given contaminant based on the characteristics of the data. Depending on the statistical distributions identified by the software application, the program provides a recommended EPC. For those cases when more than one estimate of the UCL is recommended by the software program, the first value is chosen as the UCL. When evaluating data, one-half the detection limit (USEPA, 1989) was used to represent non-detected values. The output files for each of the COPCs for human and ecological receptors from the ProUCL software are provided in the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b). A summary of the EPCs is provided in Table A-4 and Table A-5 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary" for fish and crab, respectively.

2.6.1.4 Location of Contamination and Known or Potential Routes of Migration

The Lower Passaic River is located in a highly populated area with diverse populations and may have undocumented subsistence anglers. Studies of anglers in the Passaic River and Newark Bay found that individuals are known to catch fish and crab along the river banks and from docks and bulkheads (May and Burger, 1996; Burger *et al.*, 1999; Kirk-Pflugh *et al.*, 1999). Currently, fish advisories exist in the Lower Passaic River (extending from the Dundee Dam to Newark Bay and along major tributaries to the river) that state “eat none” for fish and “do not harvest, do not eat” for crab. In the future, there are plans for area development including additional parks, which may potentially increase the availability of the areas along the river for recreational use by local residents and visitors.

The population of concern in the area of the Lower Passaic River consists of the inhabitants of the towns, cities, and industrial areas surrounding the river who may fish or engage in activities that bring them into contact with the river. From this population, "receptor" groups were defined for the purpose of quantifying the potential COPC exposures within the population as a whole. These receptor groups do not necessarily represent distinct population subgroups; rather, they are defined for convenience in presenting the exposure and risk analysis. The receptor groups are the same for both current and future scenarios where remedial alternatives are considered. The specific age groups of these populations are summarized in Section 2.6.1.7 “Exposure Assessment.”

2.6.1.5 Potentially Exposed Populations in Current and Future Scenarios and Sensitive Sub-Populations

As stated above, undocumented subsistence anglers may use the Lower Passaic River, and studies have found that anglers are known to catch fish and crab (May and Burger, 1996; Burger *et al.*, 1999; Kirk-Pflugh *et al.*, 1999). The methodology for defining receptor groups is described above.

The assessment of fish and crab consumption by the angler population includes consumption by young children (1 to 6 years), adolescents (10 to 18 years), and adults (19 years and older). Specific calculations were developed for young children (ages 1 to 6 years), assuming they consume fish caught and shared by the adult family members. Studies have found that children begin fishing at around 10 years of age (USEPA, 2000), before licenses are required (NJDEP, 2006b), so these young receptors also were included with the adult receptors and children in the HHRA. It is also possible, however, that distinct sub-populations may fish in the Area of Focus based on the identification of a homeless population in the area. This population may consume higher amounts of fish but are not explicitly identified in the creel surveys used in this analysis. This exposure route may be evaluated in the RI/FS for the 17-mile Study Area after further analysis of the creel surveys.

2.6.1.6 Exposure Routes

An exposure route is the mechanism of contact with a contaminated medium. For anglers in the Lower Passaic River area, fish ingestion (*e.g.*, dietary intake) is the exposure route evaluated. Section 2.6.1.7 “Exposure Assessment” describes the exposure assumptions used for the fish consuming population. Section 2.6.1.8 “Non-Standard Exposure Assumptions (Ingestion Rates for Crab)” describes the exposure assumptions used for the crab consuming population. For the purposes of this assessment, individuals were assumed to consume either fish or crab.

Individuals were evaluated as "recreational angler/sportsman" receptor groups in the HHRA. The angler population is defined as those individuals (male and female) who consume self-caught fish from the Lower Passaic River. In the HHRA, it was assumed that adolescents and adults would fish and crab within the Area of Focus and that part of the fish and crab caught would be shared with younger children (ages 6 years and younger). Only the angler receptor group was calculated to have exposures resulting in unacceptable risks, and therefore only this group was examined in the FFS. The complete discussion of receptor groups examined, the exposure information evaluated, and associated cancer risks and non-cancer hazards are presented in the HHRA (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b).

The collection and consumption of fish and shellfish from the Lower Passaic River has been well documented in a creel survey conducted by Belton *et al.*, (1985) for NJDEP, as well as in other published literature regarding anglers' perception of risk from contaminated fish (May and Burger, 1996; Burger *et al.*, 1999; Kirk-Pflugh *et al.*, 1999); therefore, it is clear that this exposure pathway is complete for the angler/sportsman.

2.6.1.7 Exposure Assessment

A summary of the major assumptions about exposure frequency, exposure duration, ingestion rates, body weights, and toxicity values are provided in the HHRA (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) and associated Risk Assessment Guidance for Superfund (RAGS) Part D tables (USEPA, 2001). This section describes the exposure assessment for consumers of fish only.

Ingestion Rate: The fish consumption rate was selected from the EFH (USEPA, 1997) as the RME adult (equivalent to 25 grams per day, or about 40 one half-pound fish meals per year; the 95th percentile). The recommended mean of 8 grams per day was used for the CTE (equivalent to approximately 14 one-half pound fish meals per year). The values for the EFH are based on fish ingestion studies from several different freshwater locations within the country. The ingestion rate for fish and crab identified in a more recent consumption survey (Burger, 2002) in the Lower Passaic River and Newark Bay found that 8 to 25 percent of the population ingested 1,500 grams per month, which is equivalent to 50 percent from fish and 50 percent from crab. This analysis assumes that fish consumers ingested fish only.

Ingestion rates for the adolescent and child receptors were based on the assumptions that the intake for the adolescent will be approximately two-thirds that of the adult and the intake for the child will be approximately one-third that of the adult (USEPA, 1997). These assumptions are based on the fish consumption rates provided in Table 10-1 of the EFH (USEPA, 1997) for a child aged 0 to 9 years, an adolescent from 10 to 19 years of age, and an adult aged 20 to 70+ years of age (intake averaged over six adult age groups). The selected ingestion rates are consistent with those presented in the EFH considering the specific ages of the populations being evaluated in this assessment and also are within the upper bounds of the ingestion rates at the 90th percentile or above (USEPA, 1997). Thus, for the RME, an ingestion rate of 8 grams per day is used for the child receptor, and 17 grams per day is used for the adolescent receptor. The bodyweight was adjusted to the appropriate age of the individual receptor.

<u>Exposure Duration</u>: For the exposure duration, it was assumed that the adult receptor would live in the area for a total of 30 years (24 years as an adult and 6 years as a child) consistent with the data on residential exposures. For the adolescent receptor, it was assumed that this individual would be exposed for a period of 9 years, and this exposure was evaluated separately from the overall exposure duration for adult/child assessment.

<u>Fish Species</u>: Based on consumption data from the creel angler survey (Desvousges *et al.*, 2001), the community surveys, and the extent of the historical analytical data available for each fish species, the white perch and American eel data (representing the upper and lower bounds of fish concentrations) were selected to derive an equal-weighted average concentration to represent the EPC for fish consistent with procedures used at the Hudson River.

<u>EPC</u>: See Section 2.6.1.3 "Concentrations of COPCs in Each Medium."

Specific exposure parameter values used to estimate daily intake for the RME and CTE for ingestion of fish and crab for each of the receptors (adult, adolescent, and child) are summarized in Table A-6 through Table A-11 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary."

2.6.1.8 Non-Standard Exposure Assumptions (Ingestion Rates for Crab)

The EFH (USEPA, 1997) lacks data on the consumption rate of crab. Information in the published literature regarding the consumption rates of crab is limited. Studies conducted in the Passaic River and Newark Bay area were reviewed (Burger, 2002; Burger *et al.*, 1999; and May and Burger, 1996) to identify an appropriate consumption rate. Of the studies reviewed, only the 2002 Burger study contained sufficient information regarding crab consumption in the area of the Lower Passaic River, which was used to derive a consumption rate for this Risk Assessment.

A yearly consumption rate for self-caught crab was developed (Burger, 2002) by multiplying the number of crab meals eaten per month by the number of crab eaten at each meal by the number of months per year during which crab are caught. Based on the crab consumption patterns for receptors who caught crab only, the RME ingestion rate for the adult angler/sportsman was calculated as 23 grams per day (or approximately 35 one half-pound crab per year). This value is the 95 percent UCL of the yearly consumption value (assuming the average serving size from one crab is 70 grams).

Ingestion rates for the child receptor for fish and crab were estimated assuming a rate of one-third the adult ingestion rate. The ingestion rates for the adolescent receptor were estimated using two-thirds of the adult ingestion rate. Appropriate adjustments in bodyweight were made to reflect the younger age of the child and adolescent receptors.

For crab tissue, only the blue crab is of interest because it is the only commonly caught and consumed crab in the Lower Passaic River, as evidenced by the NJDEP state consumption advisories (NJDEP, 2006a; NJDEP, 2006b). For the purposes of this Risk Assessment, human exposure to COPCs in the hepatopancreas and muscle is anticipated based on crab cooking practices. Therefore, analytical results for both types of tissue samples were combined and used to determine the EPC for crab consumption, similar to the composite sample approach described in NJDEP guidance. Section 2.6.1.3 "Concentrations of COPCs in Each Medium" provides EPC data.

2.6.1.9 HHRA Results and Uncertainties

This HHRA was conducted consistent with USEPA guidance, guidelines, and policies. The application of these procedures is designed to reduce potential uncertainty and ensure consistency. Risk results are best estimates based on the most recent information and techniques available for predicting risk. Based on the results from the RME assessment, approximate contributions to total risk from ingestion of fish and crab are 65 percent from TCDD TEQ (PCDD/F), 20 percent from TCDD TEQ (PCBs) and 10 percent from total PCBs. The risk for chlordane was estimated at 1×10^{-4}, contributing approximately 1 percent to the total risk.

The HHRA shows that, under the baseline conditions, the cancer risks and even the non-cancer hazards are expected to be above USEPA's generally acceptable levels for the 30-year period from 2007 to 2037. Chemical-specific summaries of RME and CTE cancer risk and non-cancer health hazards are provided in Table A-12 through Table A-17 in Appendix A "Supporting Tables for Human Health Risk Assessment Summary" for each receptor. Table 2.6-1 summarizes the RME risks for these populations for specific chemicals.

Table 2.6-1: Summary of the RME Risk to the Child, Adolescent, and Adult Consumers of Fish and Crab from the Lower Passaic River

Chemical	Risk for Child [1]	Risk for Adolescent [2]	Risk for Adult [3]	Total Risk for Adult and Child
Fish				
TCDD TEQ (PCDD/F)	2×10^{-3}	1×10^{-3}	5×10^{-3}	6×10^{-3}
TCDD TEQ (PCBs)	6×10^{-4}	5×10^{-4}	1×10^{-3}	2×10^{-3}
Total PCBs	3×10^{-4}	3×10^{-4}	8×10^{-4}	1×10^{-3}
4,4'-DDD	2×10^{-6}	1×10^{-6}	4×10^{-6}	6×10^{-6}
4,4'-DDE	5×10^{-6}	4×10^{-6}	1×10^{-5}	2×10^{-5}
4,4'-DDT	1×10^{-6}	1×10^{-6}	3×10^{-6}	4×10^{-6}
Total Chlordane	3×10^{-5}	2×10^{-5}	8×10^{-5}	1×10^{-4}
Dieldrin	2×10^{-5}	2×10^{-5}	5×10^{-5}	7×10^{-5}
Methyl mercury	ND	ND	ND	ND
Total	3×10^{-3}	2×10^{-3}	7×10^{-3}	1×10^{-2}

Chemical	Risk for Child [1]	Risk for Adolescent [2]	Risk for Adult [3]	Total Risk for Adult and Child
Crab				
TCDD TEQ (PCDD/F)	1×10^{-3}	1×10^{-3}	3×10^{-3}	5×10^{-3}
TCDD TEQ (PCBs)	3×10^{-3}	2×10^{-3}	7×10^{-3}	1×10^{-2}
Total PCBs	5×10^{-4}	4×10^{-4}	1×10^{-3}	2×10^{-3}
4,4'-DDD	2×10^{-6}	1×10^{-6}	4×10^{-6}	5×10^{-6}
4,4'-DDE	5×10^{-6}	4×10^{-6}	1×10^{-5}	2×10^{-5}
4,4'-DDT	4×10^{-6}	3×10^{-6}	9×10^{-6}	1×10^{-5}
Total Chlordane	6×10^{-7}	5×10^{-7}	1×10^{-6}	2×10^{-6}
Dieldrin	1×10^{-5}	1×10^{-5}	3×10^{-5}	5×10^{-5}
Methyl mercury	ND	ND	ND	ND
Total	5×10^{-3}	4×10^{-3}	1×10^{-2}	2×10^{-2}

ND – not determined.
[1] Child (aged 1-6 years)
[2] Adolescent (aged 10-18 years)
[3] Adult (over 18 years of age)

Combined carcinogenic risks reflecting total exposure to chemicals in a given medium for a given exposure pathway are summarized in Table 2.6-2.

Table 2.6-2: Summary of the CTE and RME Cancer Risks for Receptors (Child, Adolescent, and Adult) Consuming Fish and Crab from the Lower Passaic River

Pathway	CTE	RME
Fish Ingestion - cancer		
Adult [1]	4×10^{-4} (4 in 10,000)	7×10^{-3} (7 in 1,000)
Child [2]	2×10^{-4} (2 in 10,000)	3×10^{-3} (3 in 1,000)
Total	6×10^{-4} (6 in 10,000)	1×10^{-2} (1 in 100)
Adolescent [3]	2×10^{-4} (2 in 10,000)	2×10^{-3} (2 in 1,000)
Crab Ingestion - cancer		
Adult [1]	3×10^{-3} (3 in 1,000)	1×10^{-2} (1 in 100)
Child [2]	1×10^{-3} (1 in 1,000)	5×10^{-3} (5 in 1,000)
Total	4×10^{-3} (4 in 1,000)	2×10^{-2} (2 in 100)
Adolescent [3]	2×10^{-3} (2 in 1,000)	4×10^{-3} (4 in 1,000)

[1] Adult (over 18 years of age)
[2] Child (aged 1-6 years)
[3] Adolescent (aged 10-18 years)

The potential for non-carcinogenic RME risk as quantified by the hazard quotient (HQ) for each chemical in each exposure medium for each exposure pathway, as appropriate, is summarized in Table 2.6-3. The HI, which is the sum of all the HQs, also is provided for each receptor for each medium.

Table 2.6-3: Summaries of the RME Risks for Populations for Specific Chemicals

Chemical	Non-Cancer HQ for Child [1]	Non-Cancer HQ for Adolescent [2]	Non-cancer HQ for Adult [3]
Fish			
TCDD TEQ (PCDD/F)	ND	ND	ND
TCDD TEQ (PCBs)	ND	ND	ND
Total PCBs	95	52	61
4,4'-DDD	ND	ND	ND
4,4'-DDE	ND	ND	ND
4,4'-DDT	0.1	0.05	0.05
Total Chlordane	2	1	1
Dieldrin	0.3	0.2	0.2
Methyl mercury	2	1	1
Total (*i.e.*, HI)	99	55	64
Crab			
TCDD TEQ (PCDD/F)	ND	ND	ND
TCDD TEQ (PCBs)	ND	ND	ND
Total PCBs	139	72	85
4,4'-DDD	ND	ND	ND
4,4'-DDE	ND	ND	ND
4,4'-DDT	0.3	0.1	0.2
Total Chlordane	0.04	0.02	0.02
Dieldrin	0.2	0.1	0.1
Methyl mercury	0.5	0.3	0.3
Total (*i.e.*, HI)	140	72	86

ND – not determined.
[1] Child (aged 1-6 years)
[2] Adolescent (aged 10-18 years)
[3] Adult (over 18 years of age)

The potential for combined non-carcinogenic effects in each medium and exposure pathway as expressed by hazard indices, which reflect the potential additive effects of chemicals that affect the same target organ or system, is summarized in Table 2.6-4. Quantitative analysis of the non-cancer health effects from exposures to dioxins were not evaluated based on the lack of a toxicity value. This is an uncertainty that was addressed in the Risk Characterization.

Table 2.6-4: Combined Non-Carcinogenic CTE and RME Risks as Expressed by Hazard Indices

HHRA Summary for the Passaic River – Fish/Crab Ingestion Pathway		
Pathway	CTE	RME
Fish Ingestion - non-cancer		
Adult [1]	16	64
Adolescent [2]	14	55
Child [3]	25	99
Crab Ingestion - non-cancer		
Adult [1]	60	86
Adolescent [2]	53	72
Child [3]	87	140
Total HI by Organ System for Ingestion of Fish [4]		
Child [3] – Immunotoxicity	24	95
Adolescent [2] – Immunotoxicity	13	52
Adult [1] – Immunotoxicity	16	61

[1] Adult (over 18 years of age)
[2] Adolescent (ages 10-18 years)
[3] Child (ages 1-6 years)
[4] Total PCBs were the only chemicals exceeding a HQ of 1 for crab ingestion; therefore, total HI for organ system has not been provided.

Significant sources of uncertainty inherent in the HHRA are identified in Table 2.6-5 along with an indication of whether an overestimate or underestimate of cancer risk or non-cancer health hazard may be expected.

Table 2.6-5: Summary of Major Uncertainties in the HHRA and Estimated Impacts on Calculated Risks

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Exposure Assessment	EPCs for biota	95 percent UCLs on the mean were calculated from measured data collected from numerous samples distributed across the exposure area and used as the EPC to calculate risk. The difference between the 95 percent UCL and mean indicates the level of uncertainty associated with EPC estimation.	Risks for some compounds with low frequency of detection may be overestimated by using ½ the detection limit for non-detected values.
	Fish and crab tissue data used to derive EPC	Historical data used to calculate the EPC for fish may have at times included samples consisting of the whole body rather than only fillets. Historical data used to calculate the EPC for crab incorporated the hepatopancreas results.	Incorporating all portions of the fish may result in overestimating the concentrations if in fact individuals tend to mainly eat fillets or muscle tissue. Risks for ingestion of crab may be overestimated because data from the hepatopancreas-specific samples were included in the EPC.
	Use of the white perch and American eel to derive the EPC for fish ingestion	Use of a weighted average fish concentration, consisting of white perch and American eel, was used to represent a broad range of fish species that could be caught and consumed. However, the assumption is that fish species are equally caught and consumed.	Risks may be overestimated or underestimated for individuals who consume only a specific species. For example, risks for individuals who consume only white perch would be underestimated because concentrations in white perch were always higher than the American eel. A weighted average of the two fish species lowered the EPC. On the other hand, the risk for those individuals consuming only American eel would be overestimated.
	Receptors and exposure parameters	Selecting the most representative exposure parameters for the angling activities/habits is difficult, especially for exposure duration, exposure frequency, and fish ingestion rates.	Risks may be overestimated or underestimated for this site.
	Receptors and exposure parameters	Ingestion rate for consumption of crab was based on a 3-month period during which individuals reported they caught crab.	This rate did not take into consideration the number of meals eaten throughout the year when individuals continued to catch crab beyond the 3-month period or ate crab that had been caught during the 3- month period and frozen. Therefore, risks may be underestimated.
		Other potentially complete exposure pathways for the anglers were not included (*e.g.*, dermal contact with sediment). In addition, exposure to dioxin and dioxin-like compounds in sensitive subpopulations such as breast-fed children was not evaluated.	Exclusion of these additional pathways would underestimate the risks for the site.

Table 2.6-5: Summary of Major Uncertainties in the HHRA and Estimated Impacts on Calculated Risks

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Toxicity Assessment	Toxicity data (general)	Toxicity values for dioxin, PCBs, and mercury are based on an assessment of animal and human data. In some cases, animal data were used as the basis for the toxicity values that were further extrapolated to humans.	Because the most conservative values available are typically used, risks are more likely to be overestimated than underestimated.
	1998 vs. 2005 TEF values	The WHO released its re-evaluation of human and mammalian TEFs for dioxins and dioxin-like compounds performed in 2005.	Risks using the 2005 TEF values were virtually equal to those based on the 1998 values.
	Dioxin reassessment	USEPA is conducting a scientific reassessment of the health risks of exposure to dioxin and dioxin-like compounds in light of significant advances in scientific understanding of mechanisms of dioxin toxicity, significant new studies of dioxin's carcinogenic potential in humans, and increased evidence of other adverse health effects.	Future modifications for determining cancer and noncancer effects may lead to an overestimation or underestimation of risks and noncancer health hazards.
Hazard Identification	Identification of COPCs for quantitative evaluation	Only a subset of contaminants that capture the primary risk drivers were carried through the risk assessment process.	Risks are underestimated.
		COPCs associated with other environmental media (*e.g.*, sediment and surface water) were not evaluated.	Risks are underestimated.
	Mercury and methyl mercury	Due to lack of methyl mercury data in the biota tissue data, results for mercury were used as surrogate for methyl mercury based on fate and transport properties of mercury in the environment and the toxicokinetics of mercury in the biota. This assumes that all mercury contained in fish and crab eaten by humans is present as methyl mercury.	Risks are likely overestimated.

Table 2.6-5: Summary of Major Uncertainties in the HHRA and Estimated Impacts on Calculated Risks

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Risk Characterization	Distinguishing site-related risks from background and/or ambient risks	Contributions from background conditions were not assessed in the risk assessment based on the lack of information.	The calculated risks may be overestimated, but the extent of this overestimation cannot be determined.
	Consumption of both fish and crab	Risks were derived assuming that the receptors ate fish or crab, but not both.	Risks may be underestimated for individuals who eat both fish and crab. However, for individuals eating both crab and fish, the ingestion rates for both these would be expected to decrease; therefore, risks would be overestimated if the same ingestion rates were assumed.
	Thresholds that have been used for establishing consumption advisories	The information presented regarding the concentration of mercury in fish used to establish fish advisories for the general and vulnerable portions of the human population (*e.g.*, children and pregnant women) also identify potential concerns for the ingestion of mercury contaminated fish at varying concentrations.	Noncancer risks may be underestimated for vulnerable portions of the population.

2.6.1.10 Conclusion

The results of the HHRA evaluation indicate that current cancer risks and non-cancer health hazards exceed the NCP criteria for consumption of fish and crab and support the need for remedial action in the Lower Passaic River.

2.6.2 Ecological Risk Assessment Summary

The ERA conducted to support the FFS (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) evaluated direct contact exposures by sediment-associated receptors and indirect exposures to contaminated sediment (*i.e*., bioaccumulation through the food web). The indirect exposures evaluated bioaccumulation hazards to aquatic organisms that forage in the Lower Passaic River and the wildlife that consume aquatic organisms from the Lower Passaic River. Receptors of interest include sediment-dwelling and epibenthic macroinvertebrates, pelagic and demersal fish, and piscivorous wildlife (*i.e.*, mink and great blue heron). The following sections provide a summary of the major elements of the ERA.

2.6.2.1 Identification of COPECs

The initial list of COPECs identified during the ERA can be found in the Pathways Analysis Report (Battelle, 2005). This list was refined based on information discussed during the Baseline Ecological Risk Assessment workshop held in 2006 [in preparation for the development of the Draft Field Sampling Plan Volume 2 (Malcolm Pirnie, Inc., 2006b)]. Based on the refinement process, ten COPECs were identified as comprising the largest contribution to total potential risk and were carried through this assessment. These compounds had HQs that exceeded 100 for inorganic compounds and that exceeded 1,000 for organic compounds. Attachment 2 of the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) provides the complete screening process. COPECs identified for this assessment include the following:

- TCDD TEQ for PCDD/F
- TCDD TEQ for PCBs (12 dioxin-like congeners)
- Total PCB (sum of Aroclors)
- Total DDT
- Dieldrin
- LMW PAH
- HMW PAH
- Copper
- Lead
- Mercury (including methyl mercury)

For this assessment, surface sediment and biological tissue data collected from 1993 to the present were used to represent current conditions. For each sediment data set, the top (surface) sediment interval was selected. In some cases, the top interval spanned from 0-6 inches, in other cases, it spanned from 0-1 foot, and the largest interval was from 0-2.3 feet. Biological tissue data that were used consisted of crab, mummichog, American eel, and white perch samples. The analytical data for the American eel and white perch were combined together (identified as AE/WP) to represent the consumption of multiple species by the upper-level trophic level receptors (*i.e.*, mink and great blue heron). Given that there was limited variation between the American eel and white perch analytical data and the fact that a species-specific critical body residue (CBR) was unavailable for both species, the EPC that was derived for the AE/WP was also used to assess the potential risk to predatory fish. This is identified and discussed in Section 2.6.2.5 "Uncertainties Associated with the Ecological Risk Assessment."

2.6.2.2 Ecological Exposure Assessment

Receptors of Concern: A wide range of ecological receptors are potentially at risk from COPECs in the Lower Passaic River, including benthic invertebrates, fish, and a variety of piscivorous or aquatic avian and mammalian predator species. Table B-1 in Appendix B "Supporting Tables for Ecological Risk Assessment Summary" provides a summary of the ecological receptors evaluated, the associated exposure pathways, and the assessment endpoints and measurement endpoints. It should be noted that no aquatic threatened and endangered species are known to reside within the Study Area. The State of New Jersey has listed two avian species, the black crowned night heron and the American bittern, on the State's threatened and endangered species list. It is unknown if these species are present in the Study Area.

EPCs: The exposure assessment determines the degree of co-occurrence between COPECs and the ecological receptors to be evaluated. To do this, EPCs are calculated for each COPEC over the entire eight mile stretch of river. These are used to estimate exposures associated with direct contact for non-wildlife receptors (*i.e.,* fish) and are used in the food web models to estimate daily doses to wildlife receptors. The analytical data for the COPECs are presented in Table B-2 through Table B-5 in Appendix B "Supporting Tables for Ecological Risk Assessment Summary," which include summary statistics including the minimum, maximum, mean, frequency of detection, and the 95 percent upper confidence limit. The 95 percent upper confidence limit was used as the EPC for this evaluation.

2.6.2.3 Ecological Effects Assessment

Three general categories of toxicological data were used to evaluate ecological risks:

- Sediment benchmarks: used to evaluate direct contact exposures to sediment by benthic macroinvertebrates and fish.

- Toxicity Reference Values (TRVs): used to estimate toxicological effects associated with contaminant exposure by wildlife associated with the incidental sediment ingestion and contaminated prey consumption pathways.

- CBRs: used to estimate the toxicological effects associated with bioaccumulated tissue residues measured or estimated in benthic macroinvertebrates, fish, and avian eggs.

2.6.2.4 Risk Characterization

The risk characterization combines the exposure assessment with the toxicity assessment to derive a quantitative estimate of risk. Risks are derived based on both the high and low estimates of toxicity to provide a No Observed Adverse Effect Level (NOAEL) and a Lowest Observed Adverse Effect Level (LOAEL) estimate of risk. Individual risk estimates to a given receptor for each chemical and for each exposure medium are calculated and then summed to provide a total cumulative estimate of risk, the HI.

Risks to benthic invertebrates were evaluated based on sediment benchmarks developed for marine and estuarine ecosystems. The results are summarized in Table 2.6-6. Based on the magnitude of exceedance of the sediment benchmarks, dieldrin had the highest relative contribution of total risk (49.3 percent) with an HQ of 936. TCDD TEQ for PCDD/F was the next largest contributor to the total risk, comprising 26.0 percent of the overall risk. Copper and lead contributed the least, with HQs of 6.9 and 8.0, respectively.

The risk for macroinvertebrates was evaluated based on CBRs. The evaluation compared measured tissue concentrations to NOAEL and LOAEL body residue concentrations that are associated with adverse responses in morality, growth, and reproduction. The details of these analyses are provided in Attachment 5 of the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) and are summarized in Table 2.6-7. Both the LOAEL and NOAEL estimates of risk were calculated; the total HI is 5,100 for the NOAEL scenario and 540 for the LOAEL scenario. Total DDT and TCDD TEQ for PCDD/F contribute the most to the LOAEL and NOAEL HI; total DDT accounts for over 50 percent of the total HI, and the TCDD TEQ accounts for approximately 30 percent. PAHs contributed the least, with the LOAEL HI just above 1.0 for total PAHs.

Risks evaluated for forage fish (mummichog) and for the large AE/WP fish receptor are based on estimates of CBRs (Table 2.6-8 and Table 2.6-9). As discussed in the previous section for benthic invertebrates, both LOAEL and NOAEL estimates of risk were calculated for the two fish receptors based on CBR data.

For the mummichog (Table 2.6-8), the total HI is 2,200 for the NOAEL scenario and 220 for the LOAEL scenario. Copper contributes the most to the NOAEL and LOAEL (approximately 88 percent for each). PCBs contribute the next-largest portion to the total risk (7 percent), whereas pesticides (total DDT and dieldrin) and PAHs have an HQ of 1.1 or less. For the AE/WP receptor (Table 2.6-9), the total HI is 28,000 for the NOAEL scenario and 1,700 for the LOAEL scenario. Copper and total DDT account for over 90 percent of the total risk for both the LOAEL and NOAEL scenarios.

Table 2.6-6: Summary of Risk Estimates (Hazard Quotients) for Benthic Invertebrates

Habitat Type	Exposure Media	Chemical Parameter	*Marine/ Estuarine Values*		Lowest Sediment Benchmark [3] (µg/g)	Sediment EPC [4] (µg/g)	Hazard Quotient [5]	Assessment Endpoint
			NOAA ER-L [1] (µg/g)	NJDEP [2] (µg/g)				
Riverine/ Lower 8-Miles of Passaic River	Sediment and Mud Flats	Copper	34	34	34	236	6.9	Protection and mainten-ance (*i.e.*, survival, growth, and reproduc-tion) of benthic invertebrate commun-ities that serve as a forage base for fish and wildlife populations.
		Lead	47	47	47	375	8	
		Mercury	0.15	0.15	0.15	3.6	24	
		LMW PAH	0.55	-	0.55	41	74	
		HMW PAH	1.7	-	1.7	61	36	
		Total PCBs (sum of Aroclors)	0.023	0.023	0.023	1.8	79	
		Dieldrin	0.00002	-	0.00002	0.019	936	
		Total DDT	0.0016	0.0016	0.0016	0.38	239	
		TCDD TEQ (PCDD/F)	0.0000032 [6]	-	0.0000032	0.0016 [7]	493	
		TCDD TEQ (PCBs)	0.0000032 [6]	-	0.0000032	0.0000038	1.2	
		TCDD TEQ (Total)	0.0000032 [6]	-	0.0000032	0.0016	494	

ug/g = microgram per gram
(1) ER-L = Effects Range-Low from Long *et al.*, 1995.
(2) NJDEP Guidance For Sediment Quality Evaluations, November 1998. References Long *et al*. (1995).
(3) Minimum of the ER-L and the New Jersey sediment benchmark values.
(4) EPC is based on the 95 percent UCL on the arithmetic mean of the values in the assessment data set as discussed in the text. TEQs calculated using fish TEFs.
(5) HQ is the ratio of the EPC to the benchmark value.
(6) Derived by USFWS using sediment chemistry for the Arthur Kill and oyster effect data presented in Wintermyer and Cooper (2003).
(7) TCDD TEQ for dioxin is based on fish TEF.

Table 2.6-7: Summary of Risk Estimates (CBRs) for Benthic Macroinvertebrates

Habitat Type	Exposure Media	Chemical Parameter	Sediment EPC (μg/g)	Macroinvertebrates		Assessment Endpoint
				NOAEL HQ	LOAEL HQ	
Riverine/ Lower 8-Miles of Passaic River	Sediment and Contaminated Prey	Copper	236	410	41	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of benthic macroinvertebrate communities that serve as a forage base for fish and wildlife populations.
		Lead	375	1	0.1	
		Mercury	3.6	10	1	
		LMW PAH	41	6.9	0.69	
		HMW PAH	61	74	0.74	
		Total PCBs (sum of Aroclors)	1.8	13	5	
		Dieldrin	0.019	2.2	0.28	
		Total DDT	0.38	**3,000**	**300**	
		TCDD TEQ (PCDD/F)	0.0016	1500	170	
		TCDD TEQ (PCBs)	0.0000038	170	19	
		TCDD TEQ (Total)	0.0016	1670	189	
		Total HI		**5,187**	**538**	

Bolded values indicate the most significant contribution toward total risk for the receptor.

Table 2.6-8: Summary of Risk Estimates (CBRs) for Mummichog

Habitat Type	Exposure Media	Chemical Parameter	Sediment EPC (μg/g)	Mummichog		Assessment Endpoint
				NOAEL HQ	LOAEL HQ	
Riverine/ Lower 8-Miles of Passaic River	Sediment and Contaminated Prey	Copper	236	**1,900**	**190**	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of demersal, benthivorous fish populations that serve as a forage base for fish and wildlife populations.
		Lead	375	45	4.5	
		Mercury	3.6	41	4.1	
		LMW PAH	41	0.82	0.082	
		HMW PAH	61	0.31	0.031	
		Total PCBs (sum of Aroclors)	1.8	160	16	
		Dieldrin	0.019	0.00033	0.00012	
		Total DDT	0.38	0.55	0.1	
		TCDD TEQ (PCDD/F)	0.0016	2.2	0.22	
		TCDD TEQ (PCBs)	0.0000038	0.027	0.0027	
		TCDD TEQ (Total)	0.0016	2.23	0.22	
		Total HI		**2,150**	**215**	

Bolded values indicate the most significant contribution toward total risk for the receptor.

Table 2.6-9: Summary of Risk Estimates (CBRs) for AE/WP

Habitat Type	Exposure Media	Chemical Parameter	Sediment EPC (μg/g)	AE/WP		Assessment Endpoint
				NOAEL HQ	LOAEL HQ	
Riverine/ Lower 8-Miles of Passaic River	Sediment and Contaminated Prey	Copper	236	12,400	**1,200**	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of piscivorous, or semi-piscivorous fish populations that serve as a forage base for wildlife populations or sports fishery.
		Lead	375	23	2.3	
		Mercury	3.6	350	35	
		LMW PAH	41	0.82	0.082	
		HMW PAH	61	0.48	0.048	
		Total PCBs (sum of Aroclors)	1.8	1,400	140	
		Dieldrin	0.019	2.5	0.25	
		Total DDT	0.38	**13,000**	290	
		TCDD TEQ (PCDD/F)	0.0016	7.4	4.3	
		TCDD TEQ (PCBs)	0.0000038	0.15	0.088	
		TCDD TEQ (Total)	0.0016	7.55	4.4	
		Total HI		**27,184**	**1,672**	

Bolded values indicate the most significant contribution toward total risk for the receptor.

Risks calculated for the mink and the great blue heron are summarized in Table 2.6-10 and Table 2.6-11, respectively. For the mink, a diet consisting completely of piscivorous fish (*i.e.*, AE/WP) is assumed. The total HI across all chemicals and exposure scenarios is 1,600 for the NOAEL scenario and 72 for the LOAEL scenario. For both the LOAEL and NOAEL exposures, the majority of risks are associated with total TCDD TEQ (80 percent and 99 percent, respectively), with dioxin/furan compounds accounting for over 50 percent of the TEQ in both cases. Total PCBs make up 17 percent of the LOAEL risk and 1 percent of the NOAEL risk. For the LOAEL and NOAEL risks, the other COPECs (copper, mercury, lead, dieldrin, HMW PAH, LMW PAH, total DDT) have a combined HQ slightly above 1.0.

The fish consumption pathway (AE/WP) contributes the majority of the risks to the mink, accounting for 61 percent (HI_{fish} = 1,000) and 63 percent (HI_{fish} = 45) of the total risk for the NOAEL and LOAEL scenarios, respectively. Risk associated with the other evaluated pathways (*i.e.*, incidental sediment ingestion and consumption of macroinvertebrates) was considerably lower than the fish consumption pathway. Under the NOAEL scenario, the risks to the mink associated with the incidental sediment ingestion and crab consumption pathways are 120 and 500, respectively, and represent 8 percent and 31 percent of the overall risk. These pathways also make similar contributions to the overall risk estimates based on LOAELs, with the incidental sediment ingestion and crab consumption pathways accounting for 7 percent ($HI_{sediment}$ = 5) and 30 percent (HI_{crab} = 22) of the total HI, respectively. As noted above, exposure to dioxin and furan compounds accounts for a majority of risk to the mink, and the TCDD TEQ based on these compounds is also a major risk contributor (along with PCB compounds) for each pathway considered separately.

Table 2.6-10: Summary of Ecological Risk Estimates for Mink

Habitat Type	Exposure Media	Chemical Parameter	Sediment EPC (µg/kg)	Mink		Assessment Endpoint
				NOAEL HQ	LOAEL HQ	
Riverine/ Lower 8-Miles of Passaic River	Sediment and Contaminated Prey	Copper	236	1.7	1	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of piscivorous mammal populations.
		Lead	375	0.52	0.27	
		Mercury	3.6	2	0.62	
		LMW PAH	41	--	--	
		HMW PAH	61	0.04	0.04	
		Total PCBs (sum of Aroclors)	1.8	15	12	
		Dieldrin	0.019	0.53	0.26	
		Total DDT	0.38	0.2	0.04	
		TCDD TEQ (PCDD/F)	0.0016	**1,000**	**37**	
		TCDD TEQ (PCBs)	0.0000038	560	20	
		TCDD TEQ (Total)	0.0016	1560	57	
		Total HI		**1,580**	**72**	

Bolded values indicate the most significant contribution toward total risk for the receptor.

Two scenarios are evaluated for the great blue heron. The first is based on a diet consisting primarily of mummichogs, and the other is based on an AE/WP fish diet (see Table 2.6-11). For the AE/WP fish diet, the total risk is 150 for the NOAEL scenario and 16 for the LOAEL scenario. TCDD TEQ (PCBs) is the primary risk driver, contributing more than 55 percent each for the NOAEL and LOAEL risks. For the NOAEL and LOAEL scenarios, TCDD TEQ (PCDD/F) contributes 18 percent and 17 percent respectively, to the total risk. For the NOAEL scenario, the HQ for Total DDT (HQ = 20), mercury (HQ = 6.5), Total PCBs (HQ = 3.9), and lead (HQ = 1.2) were all above 1.0. For the LOAEL scenario, only the HQs for TCDD TEQ (PCB and PCDD/F) and Total DDT were greater than 1.0. The remaining compounds (mercury, lead, cooper, dieldrin, LMW PAHs, and HMW PAHs) had HQs less than 1.0.

In agreement with the findings for the mink receptor, the fish consumption pathway contributes the majority of the risks to the heron, accounting for 65 percent (HI_{fish} = 95) and 63 percent (HI_{fish} = 10) of the total risk for the NOAEL and LOAEL scenarios, respectively. Risks associated with the other evaluated pathways (*i.e.*, incidental sediment ingestion and consumption of macroinvertebrates) were considerably lower than the fish consumption pathway. Under the NOAEL scenario, the risks to the heron associated with the incidental sediment ingestion and crab consumption pathways are 14 and 38, respectively, and represent 9 percent and 26 percent of the overall risk. These pathways also make similar contributions to the overall risk estimates based on LOAELs, with the incidental sediment ingestion and crab consumption pathways accounting for 12 percent ($HI_{sediment}$ = 1.9) and 25 percent (HI_{crab} = 4.0) of the total HI, respectively. As noted above, exposure to coplanar PCBs accounts for a majority of risk to the heron, and the TCDD TEQ based on these compounds is also a primary risk contributor for each pathway considered separately.

Assuming that the great blue heron consumes primarily mummichogs, the risks are lower, with a total HI of 78 for the NOAEL scenario and 8.6 for the LOAEL scenario. As with the AE/WP fish diet, TCDD TEQ (PCBs) is the primary risk driver for the mummichog diet, contributing 59 percent to the total NOAEL risk and 53 percent to the LOAEL risk. TCDD TEQ (PCDD/F) contributes 24 percent to the NOAEL risk and 22 percent to the LOAEL risk. For the NOAEL, there is an added risk from lead, mercury, and TCDD TEQ (PCBs), with HQs above 1.0. For the LOAEL scenario, the HQs for all COPECs are below 1.0.

Table 2.6-11: Summary of Ecological Risk Estimates for Great Blue Heron

Habitat Type	Exposure Media	Chemical Parameter	Sediment EPC (µg/g)	Great Blue Heron (AE/WP Diet)		Great Blue Heron (Mummichog Diet)		Assessment Endpoint
				NOAEL HQ	LOAEL HQ	NOAEL HQ	LOAEL HQ	
Riverine/ Lower 8-Miles of Passaic River	Sediment and Contaminated Prey	Copper	236	0.97	0.32	0.52	0.17	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of aquatic bird populations.
		Lead	375	1.2	0.61	1.6	0.63	
		Mercury	3.6	6.5	0.65	3.1	0.31	
		LMW PAH	41	--	--	--	--	
		HMW PAH	61	--	--	--	--	
		Total PCBs (sum of Aroclors)	1.8	3.9	0.98	1.6	0.39	
		Dieldrin	0.019	0.039	0.00074	0.011	0.00021	
		Total DDT	0.38	20	2	6.5	0.65	
		TCDD TEQ (PCDD/F)	0.0016	27	2.7	19	1.9	
		TCDD TEQ (PCBs)	0.0000038	**87**	**8.7**	**46**	**4.6**	
		TCDD TEQ (Total)	0.0016	114	11.4	65	6.5	
		Total HI		**147**	**16**	**78**	**9**	

Bolded values indicate the most significant contribution toward total risk for the receptor.

2.6.2.5 Uncertainties Associated with the ERA

The ERA followed USEPA guidance, guidelines, and policies. Significant uncertainties inherent in the risk assessment process are summarized in Table 2.6-12. The table also identifies the projected impact of each uncertainty on the ERA conclusions (*i.e.*, whether the uncertainty results in an overestimate or underestimate of the calculated ecological risk). Although conservative assumptions were employed throughout the assessment, the limited focus of the analysis indicates that there is a low to moderate level of uncertainty in the ERA and that, overall, the risk assessment tended to underestimate ecological hazards associated with these elements.

Table 2.6-12: Summary of Major Uncertainties in the Ecological Risk Assessment and Estimated Impacts on Calculated Risks

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Problem Formulation	Identification of COPECs for quantitative evaluation	Only a subset of contaminants likely comprising the primary risk drivers at the site were selected and evaluated.	Risks are somewhat underestimated; however, exposures to the selected COPECs likely represent a substantial majority of the total hazards posed to ecological receptors.
		COPECs associated with other environmental media (*e.g.*, surface water) were not considered.	Risks are underestimated.
	Mercury and methyl mercury	Due to lack of methyl mercury data in the biota tissue data, results for mercury were used as surrogate methyl mercury. This assumes that all mercury bioaccumulated in the food chain is present as methyl mercury.	Although the hazards may be overestimated, the overall uncertainty is considered low because methyl mercury generally constitutes a substantial majority of the mercury bioaccumulated in fish tissue.
	Evaluated exposure pathways	Other potentially complete exposure pathways for fish and wildlife and fish were not included (*e.g.*, dermal contact with sediment; consumption of contaminated drinking water). In addition, exposure to dioxin and dioxin-like compounds in sensitive critical life stages (*e.g.*, fish embryos) was not explicitly evaluated.	Exclusion of these additional pathways would underestimate the risks for the site.
	Receptors and life stage evaluated	Wildlife species with foraging habits other than piscivorous were not evaluated.	It is anticipated that wildlife consumption of aquatic prey, including fish and shellfish, would result in the highest dietary exposures to COPECs; it is likely that risk to other wildlife species are of lower magnitude than reported in this assessment.
Risk Characterization	Distinguishing site-related risks from background and/or ambient risks	A portion of the estimated hazards may be attributed to the presence of naturally occurring constituents or constituents that are present at the site because of regional anthropogenic sources (*e.g.*, mercury).	The effect of including background and ambient constituents in the risk assessment is that the calculated risks overestimate the site-related risks that are due to chemical releases.
Exposure Assessment	EPCs for biota tissue	95 percent UCLs were calculated from measured data collected from numerous samples distributed across the exposure area and used as the EPC to calculate risk.	Risks for some compounds with low frequency of detection may be overestimated or underestimated because it was assumed that samples reported as "ND" contained a concentration equal to one-half the detection limit.

Table 2.6-12: Summary of Major Uncertainties in the Ecological Risk Assessment and Estimated Impacts on Calculated Risks

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Exposure Assessment	Use of a AE/WP fish composite	Use of EPCs based on a combination of AE/WP tissue data to represent exposures to piscivorous wildlife assumes that they are from the Lower Passaic River and that each of these species is equally consumed.	Risk estimates for individual mink that consume only white perch would be underestimated because concentrations in white perch were always higher than the American eel. Averaging the two fish species would therefore dilute the EPCs. On the other hand, the risk for those individuals consuming only American eel would be overestimated. Exposures would also be overestimated to the extent that wildlife receptors consumed more migratory species such as striped bass, which tend to have lower tissue COPEC concentrations.
	Receptor exposure parameters	Selecting the most representative exposure parameters for the angling activities/habits is difficult, especially for exposure duration, exposure frequency, and fish ingestion rates.	Risk estimates were based on conservative values derived from standard ecological risk guidance (USEPA, 1993a) or professional judgment. It is likely that hazards were overestimated because of the general tendency to select conservative values.
	Use of historical data	Sediment samples dating back to 1994 and biota tissue samples dating back to 1995 were used to develop EPCs in the assessment. These data are up to 12 years old and may not be representative of current conditions.	Inclusion of the historical data may tend to overestimate current exposures and hazards based on trends observed in sediment cores. Calculated multipliers to translate 1995 sediment concentrations to equivalent present-day concentrations range from 0.6 (total PCBs) to 1.0 (DDT); the estimated average multiplier for TCDD is 0.9. The use of historical data would have different impacts on the calculated risks, depending on which COPECs were identified as the primary risk drivers.
	Wildlife diet composition	Literature was referenced to quantify the relative proportion of fish and shellfish in the diets of the modeled wildlife receptors.	Ranges of estimated values generally did not differ dramatically (ranging from 0 to 30 percent in different studies, depending on the particular habitat) and the tissue EPCs are fairly comparable. However, this uncertainty has more significance for the future residual risk analysis because of significant differences in the estimated bioaccumulation factors (BAF) for higher-trophic-level fish and shellfish.

Table 2.6-12: Summary of Major Uncertainties in the Ecological Risk Assessment and Estimated Impacts on Calculated Risks

Risk Assessment Step	Source of Parameter Uncertainty	Description of Uncertainty	Impact on Calculated Risks
Exposure Assessment	Fish prey trophic level	Wading birds generally take smaller forage fish rather than larger, higher-trophic-status species. Concentrations in mummichog (a forage fish) are approximately an order of magnitude lower than in AE/WP.	Use of the fish EPCs based on a higher-trophic-level dataset likely overestimates risks to wading birds such as the heron. The magnitude of this impact was evaluated by also including an assessment of a diet that consisted of mummichogs.
Toxicity Assessment	Ingestion toxicity data	TRVs are typically based on results of tests performed on test animals and extrapolated to wildlife species; selected values are generally conservatively developed as the lowest LOAEL for well-conducted studies that evaluated ecologically relevant endpoints.	Because the most conservative values available are typically used, risks are more likely to be overestimated than underestimated. In the case of the mink receptor, well-conducted toxicity test results are available and were used to develop the TRVs.
	1998 vs. 2005 TEF values	The WHO released its re-evaluation of human and mammalian TEFs for dioxins and dioxin-like compounds performed in 2005.	An evaluation of the hazards posed based on use of the 2005 TEF values demonstrates that they are comparable to those based on the 1998 values.
	CBR effect thresholds	CBRs were selected based on a review of several large compilations of tissue residue effect data. Study quality is variable and relevance of particular endpoints uneven relative to the assessment endpoints.	Likely risks were overestimated; however, suitable tissue residue data for certain COPECs were limited and may not have included relevant sensitive species or life stages.
		Use of toxicologically unbounded study results to develop CBRs.	In several cases, NOAELs were estimated using an assumed 10-fold extrapolation factor; this may have underestimated or overestimated hazards in the assessment.
		In general, the most sensitive saltwater or estuarine fish species was selected to develop the CBRs. In many cases, CBRs are based on exposure to salmonid species that are known to be sensitive to COPECs such as dioxins, DDT, and mercury.	Species such as salmon and trout are not found in the Lower Passaic River, and hazards identified in the residue-based analysis for the AE/WP are likely overestimated. A separate set of CBRs was also developed for estuarine forage fish such as *Fundulus* spp., and CBRs for these species were, in some cases, higher than for the AE/WP (such as those for TCDD and Total DDT).

2.7 REMEDIAL ACTION OBJECTIVES AND PRELIMINARY REMEDIATION GOALS

RAOs were established to describe what the cleanup is expected to accomplish, and PRGs were developed as targets for the cleanup to meet in order to protect human health and the environment.

Risks are driven by highly contaminated surface sediment in the Lower Passaic River, and the remediation of surface sediment to the levels established by the RAOs and PRGs will significantly reduce risk to both human and ecological receptors. In addition, reduction of the source of contamination will reduce risks in Newark Bay and harborwide.

2.7.1 Remedial Action Objectives

The RAOs were developed by the USEPA with input from the partner agencies regarding current and reasonably anticipated future uses of the site. The RAOs are as follows:

- Reduce cancer risks and non-cancer health hazards for people eating fish and shellfish from the Lower Passaic River by reducing the concentration of COPCs in fish and shellfish.

- Reduce the risks to ecological receptors by reducing the concentration of COPECs in fish, shellfish and benthic organisms.

- Reduce the mass of COPCs and COPECs in sediments that are or may become bioavailable.

- Remediate the most significant mass of contaminated sediments that may be mobile (*e.g.*, erosional or unstable sediments) to prevent it from acting as a source of contaminants to the Lower Passaic River or to Newark Bay and the New York-New Jersey Harbor Estuary.

2.7.2 Preliminary Remediation Goals

PRGs provide long-term targets to use during analysis and selection of remedial alternatives. Ideally, such goals, if achieved, should both comply with ARARs and result in residual risks that satisfy the NCP requirements for the protection of human health and the environment. The PRGs were calculated considering the consumption rates for the adult consumer of fish based on the exposure assumptions used in the HHRA and also recognizing background concentrations contributed to the Lower Passaic River. Based on the comparability of the consumption rates for consumption of fish and crab, additional PRGs for consumption of crab were not included in the assessment (*i.e.*, 25 grams per day compared to 23 grams per day).

During the evaluation and development of PRGs, several human health and ecological risk-based concentration thresholds were considered. The human health PRGs were developed consistent with USEPA RAGS Part B (USEPA, 1991) and were based on the results of the HHRA (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b). The PRGs were developed for the adult angler who consumes fish or crab from the Lower Passaic River. The PRGs are summarized in Table 2.7-1, which presents the risk-based PRGs for the fish concentration, and Table 2.7-2, which provides the associated sediment concentration. For the analysis, the point of departure for cancer risks was calculated at 1 x 10^{-6} (one in one million), and the point of departure for non-cancer health hazards was a HQ equal to 1. The calculated PRGs assume that the adult ingests 40 eight ounce fish meals per year for 24 years (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b). Based on the available toxicity data, a PRG based on carcinogenic effects was calculated for Total PCB, but not for the TCDD TEQ (PCB), because: (1) the estimated risks for Total PCB and TCDD TEQ (PCB) are comparable, so that calculated PRGs using Total PCB and coplanar PCB congeners separately would not differ significantly; and (2) any remedial action based on Total PCB PRGs would address the presence of the dioxin-like PCB concerns based on co-location. Interim values assuming lower rates of consumption (*i.e.*, 1 meal per year, 2 meals per year, 6 meals per year, and 12 meals per year) were also calculated to provide concentrations for fish advisories (that may be established as an institutional control as part of the Source Control Early Action) that may be relaxed over time. These interim values are presented in the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b).

Table 2.7-1: Summary of the Human Health PRGs Developed for Fish/Crab Tissue

COPC	PRGs [1] for Fish/Crab Tissue for an Adult Angler			
	Cancer PRGs (ng/g)			Non-cancer PRGs (ng/g)
	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	
TCDD TEQ	0.000055	0.00055	0.0055	ND [2]
Total PCB	4.1	41	410	56
Chlordane	23	230	2,300	1,407
Methyl mercury	ND [3]			281

ng/g – nanograms per gram of sediment
ND – not determined.
[1] Assumes 40 eight-ounce fish or crab meals per year for 24 years.
[2] No toxicity values are available at this time.
[3] Classification - There is no quantitative estimate of carcinogenic risk from oral exposure.

Table 2.7-2: Summary of the Human Health PRGs Developed for Sediment

COPC	PRGs [1] for Sediment			
	Cancer PRGs (ng/g)			Non-cancer PRGs (ng/g)
	$1x10^{-6}$	$1x10^{-5}$	$1x10^{-4}$	
2,3,7,8-TCDD	0.00027	0.0027	0.027	ND [2]
Total PCB	1.03	10.3	103	14
Chlordane	1.2	12.0	119	72
Mercury	ND [3]			2,814

[1] Assumes 40 eight-ounce fish or crab meals per year for 24 years.
[2] No toxicity values are available at this time.
[3] Classification - There is no quantitative estimate of carcinogenic risk from oral exposure.

Separate PRGs were calculated for ecological receptors including benthic organisms and wildlife (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b). Ecological PRGs were developed for copper, lead, mercury, LMW PAH, HMW PAH, Total PCBs, Total DDT, dieldrin, TCDD TEQ for PCDD/F, and TCDD TEQ for PCBs for benthic organisms (including bivalves and crab) and for estuarine-dependent wildlife[5] (refer to Appendix B of the FFS; Malcolm Pirnie, Inc., 2007b). It was assumed that the PRGs developed for these two categories of receptors will be sufficiently protective of fish species as well. Sediment concentrations protective of benthic infauna exposed directly to various constituents were derived for marine and estuarine habitats by Long *et al*. (1995). These values, termed ER-L, represent the low end of a range of levels at which adverse effects have been observed in compiled studies. Wildlife-protective sediment concentrations for bioaccumulative COPECs were calculated with the same exposure dose equations as used in the ERA. The otter (*Lutra canadensis*) and belted kingfisher (*Ceryle alcyon*) were selected as the model receptors due to their relatively large dietary exposures to sediment-associated chemicals that can bioaccumulate in biological tissue. Table 2.7-3 presents the ecological PRGs for the selected sediment COPECs for each category of receptor considered in the ERA. The overall ecological PRG is the lower of the two values.

The toxicity data utilized in the residue-based analysis of fish tissue chemistry (*i.e.*, CBR) in the FFS (Malcolm Pirnie, Inc., 2007b) were selected as PRGs for the fish tissue medium along with back-calculated wildlife-protective values for fish tissue. Rather than deriving PRGs for TCDD using the above approach, sediment concentrations protective of piscivorous mammals (2.5 picograms per gram or parts per trillion) and birds (21 picograms per gram) derived by the USEPA (1993a) were used. The lower of these values was selected as the wildlife PRG value for fish tissue. The fish tissue PRGs

[5] Sediment PRGs for PAHs were only derived for the benthos because these compounds are not anticipated to bioaccumulate in the estuarine food web (as described in Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) to levels that would pose a threat to wildlife receptors.

presented in Table 2.7-4 include results of the residue-based (fish) and dose-based (wildlife) analyses conducted as part of the ERA.

Table 2.7-3: Summary of Sediment PRGs for Ecological Receptors

Chemical	Units	Sediment PRGs		Lowest
		Benthos [1]	Wildlife [2]	
Inorganics				
Copper	ng/g	34,000	13,318	Wildlife PRG
Lead	ng/g	46,700	10,606	Wildlife PRG
Mercury	ng/g	150	37	Wildlife PRG
PAHs				
LMW PAH	ng/g	552	-	NOAA ER-L
HMW PAH	ng/g	1700	-	NOAA ER-L
PCB Aroclors				
Total PCBs	ng/g	22.7	365	NOAA ER-L
Pesticides/Herbicides				
DDT	ng/g	1.58	19	NOAA ER-L
Dieldrin	ng/g	0.02	271	NOAA ER-L
Dioxins/Furans				
TCDD TEQ [3]	ng/g	0.0032	0.0025	Wildlife PRG

[1] Benthos PRG derived from ER-L from Long *et al.* (1995), except where noted.
[2] Derived as described in the FFS COPEC Screening Technical Memorandum (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b).
[3] Benthic benchmark for 2,3,7,8-TCDD derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper (2003); wildlife value from USEPA (1993b).

Table 2.7-4: Summary of Fish Tissue PRGs for Ecological Receptors

Chemical	Units	Fish Tissue PRGs		Lowest
		Fish [1]	Wildlife [2]	
Inorganics				
Copper	ng/g	6.3	21,935	Fish
Lead	ng/g	88	700	Fish
Mercury	ng/g	19	40	Fish
PAHs				
LMW PAH	ng/g	89	-	Fish
HMW PAH	ng/g	89	-	Fish
PCB Aroclors				
Total PCBs	ng/g	7.9	676	Fish
Pesticides/Herbicides				
DDT	ng/g	0.3	147	Fish
Dieldrin	ng/g	35	487	Fish

Chemical	Units	Fish Tissue PRGs		Lowest
		Fish [1]	Wildlife [2]	
Dioxins/Furans				
TCDD TEQ [3]	ng/g	0.050	0.0007	Wildlife

[1] Based on critical body residuals as summarized in the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b).
[2] Derived as described in the FFS COPEC Screening Technical Memorandum (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b); lowest of mammal and avian values.
[3] Low risk fish concentrations for 2,3,7,8-TCDD from USEPA (1993a).

Another consideration in the development of long-term targets is the background contamination and its contribution to the residual risks. The background contaminant contributions to a site also must be considered during PRG development to adequately understand contaminant sources and establish realistic risk reduction goals; thus, risks associated with background concentrations were estimated for human and ecological receptors and are discussed below. Investigation of contaminants in the sediment of the Upper Passaic River above the Dundee Dam revealed historic and ongoing upstream sources of metals, pesticides, and PCBs. The upstream concentrations of these contaminants are significant in comparison to their concentrations in the Lower Passaic River. USEPA guidance defines "background" as levels of chemicals that are not influenced by releases from the site, including both anthropogenic and naturally derived constituents (USEPA, 2002d). The dam physically isolates the proximal Dundee Lake and other Upper Passaic River sediments from Lower Passaic River influences while the Lower Passaic River receives contaminant loads from above the dam. The proximity of these sediments to the proposed remediation area and demonstrated geochemical connection to a portion of the Lower Passaic River sediment contamination strongly argues in favor of considering the Upper Passaic River to be background for the Lower Passaic River. Given that the contaminant concentrations detected in sediment samples recently collected from the Upper Passaic River were found to be above the risk-based thresholds, the Upper Passaic River background concentrations were selected as PRGs.

In order to determine the cancer risks and non-cancer health hazards associated with background sediment concentrations for an adult angler, biota tissue concentrations were estimated by multiplying the sediment background concentration by the chemical-specific BAF (Table 2.7-5). Cancer risks and non-cancer health hazards were estimated for ingestion of fish and crab assuming RME for only those contaminants in background for which risk-based PRGs were developed (refer to Table 2.7-1). The calculated cancer risks and non-cancer health hazards for ingestion of crab are comparable to fish ingestion based on the slightly lower ingestion rate for crabs. A summary of the cancer risk and non-cancer health hazards associated with the background concentrations are provided in Table 2.7-5. The sediment background concentration for PCBs is the only concentration associated with cancer risks and non-cancer health hazards that exceed the NCP criteria. The selection of the background concentration as opposed to risk-based PRGs emphasizes the need to investigate and remediate the area above the Dundee Dam to reduce this ongoing contribution to risks in the Lower Passaic River following remediation.

Table 2.7-5. Summary of Cancer Risks and Non-Cancer Health Hazards Associated with Sediment Background Concentrations - Ingestion of Fish/Crab for an Adult Angler

Contaminant	Sediment Background Concentration (ng/g)	BAF [1]	Estimated Fish/Crab Tissue Concentration [2] (ng/g)	Cancer Risk [3]	Non-cancer Health Hazard [3]
2,3,7,8-TCDD	0.002	0.23	0.00046	$8x10^{-6}$	ND
Total PCB	660	2.2	1452	$4x10^{-4}$	26
Chlordane	92	19.6	1803	$8x10^{-5}$	1
Mercury [4]	720	0.10	72	ND	0.3

ND – not determined because toxicity values are not available for this exposure route.
[1] Values obtained from Table 7-2 of the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b).
[2] Estimated tissue concentration derived by multiplying sediment background concentrations by the chemical-specific BAF.
[3] Cancer risks and non-cancer health hazards were estimated assuming 40 eight-ounce fish or crab meals per year for 24 years. The methodology and RME-specific exposure assumptions are described in the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b).
[4] All occurrences of mercury are assumed to be methylated for purposes of this evaluation.

Table 2.7-6 presents the estimated risks associated with background conditions for each of the representative ecological receptors and endpoints used to quantify risks in the Lower Passaic River (as discussed in Section 2.6.2.4 "Risk Characterization"). HIs for both benthic macroinvertebrates (based on sediment benchmarks and CBRs) and fish (CBRs) range from 360 to 7,900, while those for the wildlife receptors (*e.g.*, mink and heron) are considerably lower, ranging from 3.6 to 8.8. Background levels of pesticides contribute most substantially to the benthic macroinvertebrate His, with PAHs and copper of secondary importance for the analyses based on sediment benchmarks and CBRs, respectively (Table 2.7-6). Copper dominates the HIs for both fish receptor categories (approximately 88 percent and 53 percent of the mummichog and AE/WP HIs, respectively), with Total DDT also important in the case of the AE/WP category (39 percent). In the case of the mink receptor, the overall risks associated with background conditions are dominated by contributions from Total PCBs (62 percent and TCDD TEQ (22 percent, based on 2,3,7,8-TCDD). Finally, the primary contributors to the HI for the heron (under both diet scenarios) are mercury (15 to 17 percent), Total PCBs (16 to 17 percent), and Total DDT (43 to 57 percent).

Table 2.7-6: Summary of Ecological Risk Estimates [1] for Representative Receptors at Background Conditions

Chemical Parameter	Background Concentration (ug/g)	Receptor Category/Risk Basis [2]						
		Benthic Invertebrates/ Sediment Benchmarks	Benthic Invertebrates/ CBRs	Mummichog/ CBRs	AE/WP/ CBRs	Mink/ TRVs	Heron (AE/WP diet)/ TRVs	Heron (M diet)/ TRVs
Copper	80	2.3	140	640	4,200	0.58	0.33	0.18
Lead	140	3.0	0.37	17	8.6	0.19	0.45	0.6
Mercury	0.72	4.8	2.0	8.2	70	0.40	1.3	0.62
LPAHs	8.9	16	1.5	0.18	0.18	NA	NA	NA
HPAHs	65	38	79	0.33	0.51	0.043	NA	NA
Total PCBs	0.66	29	4.8	59	510	5.5	1.4	0.59
Dieldrin	0.0043	210	0.5	0.000075	0.57	0.12	0.0088	0.0025
Total DDT	0.091	57	720	0.13	3,100	0.048	4.8	1.6
2,3,7,8-TCDD [3]	0.000002	0.62	2.1	0.0028	0.0094	2.0	0.14	0.080
Total HI		360	950	730	7,900	8.8	8.4	3.6

NA – not available.

[1] Ecological risks associated with background conditions were estimated by multiplying the risk estimates for the Lower Passaic River by the ratio of the background concentrations to the EPCs presented in Table 2.6-6 through Table 2.6-11 in Section 2.6.2.4 "Risk Characterization" (*i.e.*, assuming that risks are a simple linear function of COPEC concentrations in sediment).

[2] All CBR and TRVs, used to estimate residue- and dose-based risks, respectively, are based on NOAELs.

[3] Value for 2,3,7,8-TCDD based on those for TCDD TEQ (Total); comparison assumes that only this compound contributed to the calculated TEQs for the Lower Passaic River.

As previously discussed, when the risk-based concentration thresholds were compared to the background concentrations, the background concentrations were found to be higher and were therefore selected as the PRGs. Table 2.7-7 lists the background concentrations of COPECs and COPCs, selected as the PRGs (Malcolm Pirnie, Inc., 2007b).

Table 2.7-7: Selected PRGs

Contaminant	Background Concentration (ng/g)
Copper	80,000
Lead	140,000
Mercury [1]	720
LMW PAH	8,900
LMW PAH	65,000
Total PCB	660
Total DDT	91
Dieldrin	4.3
Chlordane	92
2,3,7,8-TCDD	0.002

[1] All occurrences of mercury are assumed to be methylated for purposes of this evaluation.

The COPC and COPEC concentrations known to exist in the surface sediments of the lower eight miles are much greater than the PRGs listed in Table 2.7-7. For this reason, a remedial strategy that can reduce the concentrations to at least the level of background is necessary to begin to achieve the RAOs. The lower eight miles have been identified as a major source of contamination to the Lower Passaic River (Malcolm Pirnie, Inc., 2007a), and it has been determined that the remediation of this area (through the Source Control Early Action) would be capable of achieving acceptable risk reduction (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b).

The background levels for many of the contaminants pose unacceptable risks, in part resulting from continuing contributions from upstream sources. Thus, while the Source Control Early Action addresses the contaminated sediments of the lower eight miles of the Passaic River, a separate source control action is necessary above Dundee Dam to identify and reduce or eliminate those background sources. Such a separate action might include identifying facilities above the dam with on-going contributions to the Upper Passaic River, or conducting a track-down program where samplers are placed further and further upstream until contaminants are tracked back to specific industrial or municipal sources. Such sources would then be controlled through federal or State of New Jersey regulatory programs.

2.7.3 Evaluation of Future Risks: How RAOs and PRGs Address Risks Identified in the Risk Assessment

2.7.3.1 Evaluation of Future Human Health Risks

The purpose of this section is to evaluate the future risks in the absence of remediation and considering the declining concentrations of PCBs and dioxins based on historical data. The analysis used a model that calculated the declines in concentrations in sediments and resulting declines in concentrations in fish. The calculated concentrations provide a means of comparing No Action to the active remedial alternatives. This section describes the development of the future concentrations and risks for the adult fish consumer.

USEPA examined risks to human health in the absence of remedial action in the HHRA for the FFS (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b). The Risk Assessment concluded that current and future concentrations of dioxins and PCBs in fish and crab are above levels of concern to human health, and consumption of contaminated fish and crab is the primary exposure pathway.

The HHRA found dioxins and PCBs are the main COPCs. The evaluation conditions are equivalent to the No Action remedial alternative and presume no remediation of the contaminated sediments in the eight mile Area of Focus and no additional source control measures at the sources. Consistent with the NCP, the conditions for the HHRA also do not include institutional controls, such as the current fish consumption advisories, because institutional controls are designed to control exposure and are considered to be limited action alternatives.

Building on the information from the HHRA, a future risk assessment was developed in the FFS to compare the reductions in risk considering No Action versus active remedial alternatives. The results of the future risk assessment will be used to assist risk management decisions regarding the selection of a remedial action. Potential future risks to human health were calculated assuming three remediation scenarios:

- No Action
- Active Remediation of the Primary Erosional Zone and/or the Primary Inventory Zone
- Active Remediation of the Area of Focus

The future risk evaluation [also presented in the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b)] used the same set of COPCs and the same risk assessment methodology, including potential exposure scenarios and assumptions that were evaluated in the current risk evaluation.

Future chemical concentrations in fish and crab were estimated using projections of current sediment data; however, unlike the current risk assessment, the future risk assessment assumes declining concentrations of the COPCs over time to allow an analysis of monitored natural recovery. A description of the empirical mass balance approach used to estimate surface sediment concentrations is provided in the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b).

In general, several sets of future EPCs were developed for each of the COPCs, corresponding to each of the remediation scenarios (*i.e.*, remediation of the Primary Erosional Zone and/or the Primary Inventory Zone; remediation of the Area of Focus; and No Action) at three time periods. The first time period was selected to represent the year remediation is expected to be complete (*i.e.*, 2018). For the first time period, predicted average annual concentrations at 2018 are used to represent concentrations for that specific period in time. Future EPCs for subsequent time periods need to consider the exposure duration (*i.e.*, "ED") component of the risk/hazard equation which is assessed differently for cancer risk and non-cancer hazard. To derive EPCs to estimate future cancer risks, the predicted average annual concentrations derived from years 2019 through 2048 are used to derive an average concentration over the total exposure duration of 30 years (*i.e.*, 6 years as a child and 24 years as an adult). Thus, a 6-year average of the average annual sediment concentrations is used for the child, and a 24-year average of the average annual sediment concentrations is used to represent the adult for cancer exposure only.

The future EPCs for COPCs in fish and crab are based upon modeled projections of future concentrations in sediment. As such, the approach used to determine EPCs for the current risk scenarios where USEPA guidance was followed for determining the underlying population distribution could not be followed to derive the future EPCs. Therefore, an approach was developed to relate the future EPCs based on an average concentration to a 95 percent UCL (USEPA, 1989). In general, the approach consisted of taking the predicted average annual sediment concentrations and multiplying them by the ratio of the current sediment 95 percent UCL concentrations to the current mean sediment concentrations to obtain a future 95 percent UCL estimate in sediment. Note that this approach most likely overestimates future 95 percent UCL concentrations for remediation of the Primary Erosional Zone and/or the Primary Inventory Zone and the remediation of the Area of Focus scenarios because future sediment concentrations will have a substantially smaller range, and therefore a smaller confidence interval than current sediment concentrations. This is because, as defined, the remediation will remove excessively high sediment chemical concentrations.

The future 95 percent UCLs for biota were then derived by multiplying the future estimated 95 percent UCLs in sediment by chemical-specific BAFs. The BAFs were derived as the ratio of the current biota (*i.e.,* piscivorous, forage, and crab) mean tissue concentrations to the current mean sediment concentrations.

For estimating non-cancer health hazards, the predicted average annual concentrations derived from years 2019 through 2024 and 2019 through 2025 are used to derive EPCs for the child and adult receptors, respectively. For non-carcinogens, the averaging time (AT) for the child is 6 years, while the AT for the adult is averaged over a period equal to a chronic exposure duration (7 years). Therefore, the AT for the non-cancer hazard assessment for the adult is set to 2,555 days (7 years x 365 days per year). As the duration of exposure increases, the EPC and thus the average daily dose decreases, allowing the intake to be averaged over a longer period of time (*i.e*., greater than 7 years). Since this would underestimate the RME risk to the adult, only a 7-year exposure duration (as opposed to a 24-year exposure duration) is assumed for the adult for non-carcinogenic exposures occurring through the year 2048. Based on this same principle, the first 7 years after remediation, rather than the second or third 7-year period, is used to determine the EPCs for assessing a RME to the adult and child receptors. Because the EPC and thus the average daily dose decreases over time (which only impacts exposure to non-carcinogens) a third set of EPCs is derived for the adult to provide a lower bound on risk at a period in time closer to 2048. While the first 7 years post-remediation is used to derive an EPC representing the RME for the adult, the last 7-year period (*i.e*., 2042-2048) is used to derive a second EPC for the adult. This EPC is more representative of the actual concentrations 30 years post-remediation. Only the adult receptor is evaluated for the 2042-2048 time period to assist risk management decisions regarding the selection of a remedial action.

Results from the current risk evaluation were then used as a baseline to assess the relative risk reduction afforded by the No Action alternative, by active remediation of the Primary Erosional Zone and/or Primary Inventory Zone, or by active remediation of the Area of Focus. Table 2.7-8 presents a summary of the future risk/hazard for each alternative, along with a comparison of the relative reduction in risk/hazard compared to baseline.

Table 2.7-8: Summary of Baseline and Future Cancer Risk and Non-Cancer Health Hazards and the Relative Reductions in Risk/Hazard after 30 Years

Fish Consumption	Time Period [1]	Adult + Child Combined Risk	Adult Hazard	Child Hazard	Relative Reduction [2] Combined Risk	Relative Reduction [2] Adult Hazard	Relative Reduction [2] Child Hazard
No Action Alternative [3]	2018	6×10^{-3}	24	37	42%	63%	63%
	2019-2025	4×10^{-3}	20	31	64%	69%	69%
	2042-2048		7	ND [4]		89%	ND [4]
Active Remediation of Primary Erosional Zone/Primary Inventory Zone	2018	4×10^{-3}	21	33	58%	67%	67%
	2019-2025	2×10^{-3}	18	29	75%	72%	71%
	2042-2048		6	ND [4]		91%	ND [4]
Active Remediation of Area of Focus	2018	9×10^{-4}	16	25	91%	75%	75%
	2019-2025	5×10^{-4}	14	22	95%	79%	78%
	2042-2048		5	ND [4]		92%	ND [4]
Baseline [5]		1×10^{-2}	64	99			
Crab Consumption	**Time Period [1]**	**Adult + Child Combined Risk**	**Adult Hazard**	**Child Hazard**	**Relative Reduction [2] Combined Risk**	**Relative Reduction [2] Adult Hazard**	**Relative Reduction [2] Child Hazard**
No Action Alternative	2018	4×10^{-3}	19	31	78%	77%	78%
	2019-2025	3×10^{-3}	16	27	87%	81%	81%
	2042-2048		5	ND [4]		94%	ND [4]
Active Remediation of Primary Erosional Zone/Primary Inventory Zone	2018	3×10^{-3}	17	28	84%	80%	80%
	2019-2025	2×10^{-3}	14	24	91%	83%	83%
	2042-2048		5	ND [4]		94%	ND [4]
Active Remediation of Area of Focus	2018	8×10^{-4}	13	21	96%	85%	85%
	2019-2025	4×10^{-4}	11	19	98%	87%	87%
	2042-2048		4	ND [4]		95%	ND [4]
Baseline [5]		2×10^{-2}	86	140			

The approach used to estimate risk/hazard for human receptors is provided in the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b).

[1] The time period 2018 represents the year remediation is expected to be complete and the predicted average annual concentrations at 2018 are used as the EPCs. For 2019-2048, the predicted average annual concentrations derived from years 2019 through 2048 are used to derive an average concentration over the total exposure duration of 30 years (*i.e*., 6 years as a child and 24 years as an adult). Thus, a 6-year average of the average annual sediment concentrations is used for the child, and a 24-year average of the average annual sediment concentrations is used to represent the adult for cancer exposure only.

[2] Baseline conditions compared to estimated condition 30 years following implementation.

[3] Detailed discussion of the remedial alternatives is provided in Section 2.8 "Description of Remedial Alternatives."

[4] ND – not determined. Only the adult receptor is evaluated for non-cancer health hazards for the 2042-2048 time period to assist risk management decisions regarding the selection of a remedial action. The health hazard for the adult, rather than the child, may be more heavily relied upon for risk management decisions because datasets supporting the ingestion rates are available for an adult, but not a child receptor.

[5] The current scenario is assumed to represent the risks in 2007, before remediation is initiated and prior to accounting for natural degradation (*e.g.*, monitored natural recovery). Current risk represents the RME.

Evaluation of Future Human Health Risks due to Upper Passaic River Source Track-Down Program and Remediation

To be addressed.

2.7.3.2 Evaluation of Future Ecological Risks

The future ecological risk evaluation [also presented in the Risk Assesment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b)] used the same set of COPECs, exposure factors, and toxicity benchmarks that were used to assess current ecological risks and were also employed to estimate potential future hazards associated with each remedial alternative being considered. Results from the assessment of current conditions were then used to evaluate the relative reduction in hazards associated with each alternative to aid in decision-making. Consistent with the assessment of current conditions, three broad ecological receptor categories were evaluated: macroinvertebrates, fish, and aquatic-dependent wildlife.

Ecological risks are estimated for two future time points: immediately following the completion of the remedial actions (*i.e.*, 2018) and 30 years thereafter (*i.e.*, 2048). Where possible, the estimated hazards are bounded by presenting estimates based both on NOAEL- and LOAEL-based toxicity values.

As discussed previously for the human health assessment, the future chemical concentrations in sediment were estimated from the EMBM using current sediment data and modeled to fish and crab tissue; however, unlike the current risk assessment, the future risk assessment assumes declining concentrations of the COPCs over time. The estimated futurecast hazard estimates for each receptor are provided in Table C-1 through Table C-6 in Appendix C "Supporting Tables for Estimates of Future Hazards for Ecological Receptors."

Protective concentrations for COPECs in sediment and fish tissue (Table 2.7-9 and Table 2.7-10, respectively) were developed for the protection of benthic organisms (including bivalves) and for estuarine-dependent wildlife for the subset of COPECs that are capable of bioaccumulating (*i.e.,* all except PAHs) in estuarine biota. It was assumed that the protective concentrations developed for these two categories of receptors will be sufficiently protective of fish species as well.

Table 2.7-9: Sediment COPEC Concentrations Expected to Provide Adequate Protection of Ecological Receptors

Habitat Type	Exposure Media	Chemical Parameter	Back-ground Concen-tration	Units	Sediment Protective Levels		Basis	Assess-ment Endpoint
					Benthos [1]	Wildlife		
Riverine/ Lower 8-Miles of Passaic River	Sediment	Copper	80,000	ng/g	34,000	13,318	Wildlife dose assessment	Protection and mainten-ance (*i.e.*, survival, growth, and reproduc-tion) of
		Lead	140,000	ng/g	46,700	10,606	Wildlife dose assessment	
		Mercury	720	ng/g	150	37	Wildlife dose assessment	

Habitat Type	Exposure Media	Chemical Parameter	Back-ground Concen-tration	Units	Sediment Protective Levels		Basis	Assess-ment Endpoint
					Benthos [1]	Wildlife		
		LMW PAH	8,900	ng/g	552	-	NOAA ER-L	benthic inverte-brate commun-ities that serve as a forage base for fish and wildlife popula-tions and aquatic birds and mammals.
		HMW PAH	65,000	ng/g	1700	-	NOAA ER-L	
		Total PCBs (sum of Aroclors)	660	ng/g	22.7	365	NOAA ER-L	
		Dieldrin	4	ng/g	0.02	271	NOAA ER-L	
		Total DDT	91	ng/g	1.58	19	NOAA ER-L	
		TCDD TEQ [2]	0.002	ng/g	0.02	271	Wildlife dose assessment	

[1] ER-L from Long *et al.*, 1995, except where noted.

[2] Benthic benchmark for 2,3,7,8-TCDD derived by USFWS using sediment chemistry for Newark Bay and oyster effect data presented in Wintermyer and Cooper (2003); wildlife value from USEPA (1993b).

Table 2.7-10: Fish Tissue COPEC Concentrations Expected to Provide Adequate Protection of Ecological Receptors

Habitat Type	Exposure Media	Chemical Parameter	Background Concentration	Units	Fish Tissue Protective Levels		Basis	Assessment Endpoint
					Fish	Wildlife		
Riverine/ Lower 8-Miles of Passaic River	Fish Tissue	Copper	80,000	ng/g	6.3	21,935	CBR in fish	Protection and maintenance (*i.e.*, survival, growth, and reproduction) of fish and aquatic birds and mammals.
		Lead	140,000	ng/g	88	700	CBR in fish	
		Mercury	720	ng/g	19	40	CBR in fish	
		LMW PAH	8,900	ng/g	89	-	CBR in fish	
		HMW PAH	65,000	ng/g	89	-	CBR in fish	
		Total PCBs (sum of Aroclors)	660	ng/g	7.9	676	CBR in fish	
		Dieldrin	4	ng/g	35	487	CBR in fish	
		Total DDT	91	ng/g	0.3	147	CBR in fish	
		TCDD TEQ [1]	0.002	ng/g	0.05	0.0007	Wildlife dose assessment	

[1] Low risk fish concentrations for 2,3,7,8-TCDD from USEPA (1993a).

In summary, six sets of future EPCs were developed for each COPEC, corresponding to each of the three remediation scenarios at two time periods (*i.e.,* 2018 and 2048).

The following general conclusions were obtained from the risk assessment:

- In all instances, the Area of Focus remediation scenario resulted in the greatest reduction in ecological hazards. Furthermore, ecological improvements are predicted to occur in a substantially shorter period of time.

- None of the remediation scenarios would result in a condition of no significant risk of harm for any of the ecological receptors over the time periods assessed; however, by the year 2048, it is anticipated that wildlife receptors would have a hazard reduction of 78 to 98 percent for the Area of Focus remediation scenario.

Ecological hazards associated with the Area of Focus scenario are estimated to be one to two orders of magnitude lower than those associated with the No Action scenario.

Table 2.7-11 presents a summary of the geometric mean of the NOAEL and LOAEL HI calculated for the evaluated receptors for current conditions and for each of the three selected remedial scenarios. The geometric mean is used here to present the risk based on a single effect level. These findings strongly support a conclusion that ecological receptors that reside in the river currently are being adversely impacted as a result of exposure to COPECs associated with the river sediment and biological tissue. With respect to the evaluation of future remedial scenarios, the Area of Focus scenario resulted in the greatest reduction in ecological hazards and ecological improvements are predicted to occur in a substantially shorter period of time. None of the remedial scenarios would result in a condition of no significant risk of harm for any of the ecological receptors over the time periods assessed; however, by the year 2048, it is anticipated that wildlife receptors would have a hazard reduction of 78 to 98 percent for remediation of the Area of Focus. Separate source control actions above Dundee Dam, when implemented, will accelerate the time frame within which the active remedial alternatives for the Area of Focus will reach the condition of no significant risk of harm for the ecological receptors.

Table 2.7-11: Summary of Ecological Hazards Associated with Current Conditions and Various Remedial Scenarios

Receptor/ Endpoint	Remedial Scenario [1]	Baseline Hazard [2]	Estimated Future Hazard [2]		Hazard Reduction [3]
			2018	2048	
Macroinvertebrates/sediment benchmarks					
	Monitored Natural Recovery	1,898	1,577	1,259	34%
	Primary Erosional Zone/Primary Inventory Zone		1,388	1,160	39%
	Area of Focus		383	326	83%
Macroinvertebrates/CBRs [4]					
	Monitored Natural Recovery	1,665	771	261	84%
	Primary Erosional Zone/Primary Inventory Zone		612	220	87%
	Area of Focus		199	78	95%
Fish (AE/WP)/CBRs					
	Monitored Natural Recovery	6,858	2,637	1,054	85%
	Primary Erosional Zone/Primary Inventory Zone		2,373	955	86%
	Area of Focus		1,215	497	93%
Fish (mummichog)/CBRs					
	Monitored Natural Recovery	694	703	302	56%
	Primary Erosional Zone/Primary Inventory Zone		646	279	60%
	Area of Focus		352	155	78%
Mammal (mink)/ingestion dose modeling					
	Monitored Natural Recovery	339	166	52	85%
	Primary Erosional Zone/Primary Inventory Zone		121	34	90%
	Area of Focus		22	6	98%
Bird (heron)/ingestion dose modeling					
	Monitored Natural Recovery	49	17	5	89%
	Primary Erosional Zone/Primary Inventory Zone		14	4	92%
	Area of Focus		6	2	96%

[1] A detailed discussion of the remedial alternatives is provided in Section 2.8 "Description of Remedial Alternatives."

[2] The approach used to estimate ecological hazards is provided in the Risk Assessment (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b). Where bounding estimates of the hazards were derived, the geometric mean of the upper and lower bounds are provided above.

[3] Compared to baseline conditions after 30 years.

[4] CBR are threshold tissue concentrations above which adverse effects have been reported in the literature.

Evaluation of Future Ecological Risks due to Upper Passaic River Source Track-Down Program and Remediation

To be addressed.

2.8 DESCRIPTION OF REMEDIAL ALTERNATIVES

In addition to the No Action alternative, six active remedial alternatives were developed in the FFS and are described below. The active remedial alternatives were developed to target the fine-grained sediment present in the Area of Focus by dredging, capping, or a combination of these options. The remedial alternatives and cost estimates were developed as part of the FFS (Malcolm Pirnie, Inc., 2007b).

Two DMM scenarios incorporating nearshore confined disposal facility (CDF) disposal were considered in developing the cost estimates. DMM Scenario A assumes the all dredged material would be permanently disposed of in a CDF. DMM Scenario B assumes that all dredged material would initially be placed in a CDF, but the volume stored above the original mudline grade (prior to excavation within the CDF footprint) would be dewatered and treated by an onsite thermal treatment facility. The volume to be thermally treated under DMM Scenario B is up to approximately 1.7 million cy (*in-situ*). When necessary to provide the required capacity, excavation below the mudline (within the footprint of the CDF) would be performed.

Alternative 1 – Removal of Fine-Grained Sediment from Area of Focus

Alternative 1 would use mechanical dredging to remove fine-grained sediment from the Area of Focus.

Within the horizontal limits of the federally authorized navigation channel, the depth of fine-grained sediment corresponds well with the depth of historical dredging. For this reason, the depth of dredging within these horizontal limits is assumed to be the historically constructed channel depth plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot).

Outside of the horizontal limits of the federally authorized navigation channel, the depth of fine-grained sediment varies. Therefore, data from geotechnical cores and chemical cores were used to estimate the depth of the fine-grained sediment boundary at various locations in the river. The depth of dredging at each of these locations is the estimated depth of fine-grained sediment plus an additional one foot to account for dredging accuracy.

The objective of Alternative 1 is to remove as much of the fine-grained sediment as practicable, resulting in the exposure of the underlying sandy material. As soon as practicable after exposure of this sandy material, two feet of backfill material would be placed to mitigate residual contamination. The thickness of this backfill material would not be monitored or maintained following implementation.

The dredged material removed during implementation of Alternative 1 would be placed into a nearshore CDF. After the material is passively dewatered, it may either be removed from the CDF for thermal treatment (DMM Scenario B), or it may be permanently capped in place (DMM Scenario A).

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories, while MNR processes act to reduce the concentration of the remaining contamination until the RAOs are achieved. A long-term monitoring program would be implemented to verify that the river is responding with reduced contamination levels over the long term. A review of site conditions would be conducted at five-year intervals, as required by CERCLA.

A portrayal of Alternative 1 is shown on Figure 2.8-1, and the costs and schedule for Alternative 1 are summarized in Table 2.8-1. Alternative 1 involves the removal of approximately 10,960,000 cy of dredged material and the placement of approximately 2,100,000 cy of backfill material and 208,000 cy of mudflat reconstruction material.

Table 2.8-1: Summary of Costs and Construction Time for Alternative 1

Costs	DMM Scenario A	DMM Scenario B
Total Capital Costs:	$1,092,000,000	$1,092,000,000
Total DMM Costs:	$763,000,000	$1,085,000,000
Total O&M Costs:	$91,000,000	$95,000,000
Total Present Worth Costs (5 Percent Rate over 30 Years):	$1,947,000,000	$2,272,000,000
Construction Time:	12 years	12 years

O&M – Operations and maintenance

Alternative 2 – Engineered Capping of Area of Focus

Alternative 2 would sequester the contaminated sediments in the Area of Focus under an engineered cap. Minimal removal of contaminated sediments, for the purposes of mudflat reconstruction and armor placement only, is assumed for Alternative 2.

The cap would be constructed of sand, stone, and mudflat reconstruction material. Over approximately 80 percent of the sediment surface area, the cap would be constructed of sand alone. In areas of unacceptable erosion, estimated to be approximately 20 percent of the river surface in Appendix G of the FFS (Malcolm Pirnie, Inc., 2007b), stone would be used as armor material. In select small areas of the river, existing mudflats would be reconstructed by removing 3 feet of contaminated sediment, placing 1.5 feet of sand as substrate, and placing 1 foot of mudflat reconstruction material.

It has been assumed that placement of sand material would be conducted using conventional methods, which would be capable of minimizing the amount of settlement of the sand material into the existing silt. Placement of armor material would be achieved using mechanical methods. Due to the proximity to shore, mudflat reconstruction material would likely be placed via mechanical equipment.

The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program.

Flood modeling as described in Appendix G of the FFS (Malcolm Pirnie, Inc., 2007b) has shown that pre-dredging prior to cap placement does not substantially reduce the total area flooded relative to existing conditions. Therefore, pre-dredging in areas to be capped has not been incorporated into Alternative 2.

The dredged material removed during implementation of Alternative 2 would be placed into a nearshore CDF. After the material is passively dewatered, it may either be removed from the CDF for thermal treatment (DMM Scenario B), or it may be permanently capped in place (DMM Scenario A).

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while MNR processes act to reduce the concentration of the remaining contamination until the RAOs are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained, and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of site conditions would be conducted at five-year intervals, as required by CERCLA.

A portrayal of Alternative 2 is shown on Figure 2.8-2, and the costs and schedule for Alternative 2 are summarized in Table 2.8-2. Alternative 2 involves the removal of approximately 1,142,000 cy of dredged material and the placement of approximately

3,151,000 cy of capping material, 623,000 cy of armor material, and 208,000 cy of mudflat reconstruction material.

Table 2.8-2: Summary of Costs and Construction Time for Alternative 2

Costs	DMM Scenario A	DMM Scenario B
Total Capital Costs:	$537,000,000	$537,000,000
Total DMM Costs:	$230,000,000	$477,000,000
Total O&M Costs:	$96,000,000	$97,000,000
Total Present Worth Costs (5 Percent Rate over 30 Years):	$863,000,000	$1,111,000,000
Construction Time:	6 years	6 years

Alternative 3 – Engineered Capping of Area of Focus Following Reconstruction of Federally Authorized Navigation Channel

The dimensions of the federally authorized navigation channel are provided in Section 2.5.2.1 "Current Federally Authorized and Constructed Navigation Channel." Alternative 3 would use mechanical dredging to remove sediment from within the horizontal limits of the federally authorized navigation channel. The depth of dredging within these horizontal limits is assumed to be the historically constructed channel depth plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The sediment surface between the bottom of the dredged channel and the existing sediment surface ("sideslope") would be constructed at a slope of 3 horizontal to 1 vertical (3H:1V).

After sediments are removed from the federally authorized navigation channel to the depth specified above, it is assumed that a minimal amount of fine-grained sediment would remain in the channel. Therefore, a two-foot backfill layer would be placed to mitigate remaining fine-grained sediment and dredging residuals. The thickness of this backfill material would not be monitored or maintained following implementation.

Outside of the horizontal limits of the federally authorized navigation channel, however, it is possible that additional, un-targeted contaminant inventory would remain in place. For this reason, it is assumed that an engineered cap would be placed on the sideslopes, as well as on the existing sediment surface between the channel and the shoreline ("shoal"). In areas of unacceptable erosion on the sideslopes and/or shoals, as identified in Appendix G of the FFS (Malcolm Pirnie, Inc., 2007b), stone would be used as armor material. The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program.

The dredged material removed during implementation of Alternative 3 would be placed into a nearshore CDF. After the material is passively dewatered, it may either be removed from the CDF for thermal treatment (DMM Scenario B), or it may be permanently capped in place (DMM Scenario A).

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while MNR processes act to reduce the concentration of the remaining contamination until the RAOs are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained, and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of site conditions would be conducted at five-year intervals, as required by CERCLA.

A portrayal of Alternative 3 is shown on Figure 2.8-3, and the costs and schedule for Alternative 3 are summarized in Table 2.8-3. Alternative 3 involves the removal of approximately 6,979,000 cy of dredged material and the placement of approximately 2,702,000 cy of backfill material, 52,000 cy of armor material, and 208,000 cy of mudflat reconstruction material.

Table 2.8-3: Summary of Costs and Construction Time for Alternative 3

Costs	DMM Scenario A	DMM Scenario B
Total Capital Costs:	$901,000,000	$901,000,000
Total DMM Costs:	$522,000,000	$847,000,000
Total O&M Costs:	$94,000,000	$97,000,000
Total Present Worth Costs (5 Percent Rate over 30 Years):	$1,518,000,000	$1,845,000,000
Construction Time:	8 years	8 years

Alternative 4 – Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage

As described in the FFS (Malcolm Pirnie, Inc., 2007b), USACE-New York District has estimated the dimensions of the navigation channel necessary to accommodate current usage. Alternative 4 would use mechanical dredging to construct a channel of these dimensions, and subsequently place an engineered cap over the entire Area of Focus.

From RM0 to RM1.2, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the historically constructed channel depth (30 feet MLW) plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The sideslope would be constructed at a slope of 3H:1V. After sediments are removed from the federally authorized navigation channel to the depth specified above, it is assumed that a minimal amount of fine grained sediment would remain in the channel. Therefore, a two-foot backfill layer would be placed to mitigate remaining fine grained sediment and dredging residuals. The thickness of this backfill material would not be monitored or maintained following implementation.

From RM1.2 to RM2.5, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the depth required by the design vessel (13 feet), plus an additional three feet for underkeel clearance, plus an additional nine feet to accommodate the necessary cap components that would be placed. The sideslope would be constructed at a slope of 3H:1V. Following removal to the depth described above, it is possible that additional, un-targeted contaminant inventory could remain in place. Therefore, an engineered cap would be placed on the channel bottom. The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program.

In the sideslope and shoal areas of RM0 to RM2.5, and throughout the rest of the Area of Focus from RM2.5 to RM8.3, it is likely that additional, un-targeted contaminant inventory would remain in place. Therefore, pre-dredging to accommodate an engineered cap would be necessary in these areas. In areas of unacceptable erosion, as identified in Appendix G of the FFS (Malcolm Pirnie, Inc., 2007b), stone would be used as armor material.

The dredged material removed during implementation of Alternative 4 would be placed into a nearshore CDF. After the material is passively dewatered, it may either be removed from the CDF for thermal treatment (DMM Scenario B), or it may be permanently capped in place (DMM Scenario A).

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while MNR processes act to reduce the concentration of the remaining contamination until the RAOs are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained, and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of site conditions would be conducted at five-year intervals, as required by CERCLA.

A portrayal of Alternative 4 is shown on Figure 2.8-4, and the costs and schedule for Alternative 4 are summarized in Table 2.8-4. Alternative 4 involves the removal of approximately 4,432,000 cy of dredged material and the placement of approximately 3,080,000 cy of capping material, 429,000 cy of armor material, and 208,000 cy of mudflat reconstruction material.

Table 2.8-4: Summary of Costs and Construction Time for Alternative 4

Costs	DMM Scenario A	DMM Scenario B
Total Capital Costs:	$754,000,000	$754,000,000
Total DMM Costs:	$418,000,000	$744,000,000
Total O&M Costs:	$95,000,000	$97,000,000
Total Present Worth Costs (5 Percent Rate over 30 Years):	$1,267,000.000	$1,596,000,000
Construction Time:	6 years	6 years

Alternative 5 – Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage

As described in the FFS (Malcolm Pirnie, Inc., 2007b), the State of New Jersey has estimated the dimensions of the navigation channel necessary for future river traffic. Alternative 5 would use mechanical dredging to construct a channel of these dimensions, and place an engineered cap or backfill over the Area of Focus.

From RM0 to RM1.2, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the historically constructed channel depth (30 feet MLW) plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The channel sides would be constructed at a slope of 3H:1V. After sediments are removed from the federally authorized navigation channel to the depth specified above, it is assumed that a minimal amount of fine grained sediment would remain in the channel. Therefore, a two foot backfill layer would be placed to mitigate remaining fine grained sediment and/or dredging residuals. The thickness of this backfill material would not be monitored or maintained following implementation.

From RM1.2 to RM2.5, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the depth required by the design vessel (13 feet), plus an additional three feet for underkeel clearance to achieve the channel depth of 16 feet MLW, plus an additional nine feet to accommodate the necessary cap components that would be placed. The channel sides would be constructed at a slope of 3H:1V. Following removal to the depth described above, it is possible that additional, un-targeted contaminant inventory would remain in place. Therefore, an engineered cap would be placed on the channel bottom. The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program.

From RM2.5 to RM3.6, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the historically constructed channel depth (20 feet MLW) plus an additional three feet to account for historical overdredging (two feet) and dredging accuracy (one foot). The sideslope would be constructed at a slope of 3H:1V. After sediments are removed from the federally authorized navigation channel to the depth specified above, it is assumed that a minimal amount of fine grained sediment would remain in the channel. Therefore, a two-foot backfill layer would be placed to mitigate remaining fine grained sediment and dredging residuals. The thickness of this backfill material would not be monitored or maintained following implementation.

From RM3.6 to RM8.3, the depth of dredging within the horizontal limits of the federally authorized navigation channel is assumed to be the depth required by the design vessel (seven feet), plus an additional three feet for underkeel clearance, plus an additional nine feet to accommodate the necessary cap components that would be placed. This alternative will require sediment removal to 19 feet MLW. However, the depth of the authorized historical channel from RM8.1 to RM8.3 is 10 feet. An addition of three feet to the authorized depth to account for historical overdredging (two feet) and dredging accuracy (one foot) result in a historical channel depth of 13 feet MLW (not 19 feet MLW). Since dredge depth is limited to the historical channel depth, it is assumed that sediment will be removed to a depth of 13 feet MLW from RM8.1 to RM8.3. Following removal to the depth described above (*i.e.*, 19 feet MLW from RM3.6 to RM8.1 and 13 feet from RM8.1 to RM8.3), it is possible that additional, un-targeted contaminant inventory would remain in place from RM3.6 to RM4.6; however, it is assumed that minimal fine-grained sediment would remain in the channel from RM4.6 to RM8.3. Therefore, an engineered cap would be placed on the channel bottom from RM3.6 to RM4.6 and a two foot backfill layer would be placed to mitigate for any remaining fine-grained sediment and/or dredging residuals from RM4.6 to RM8.3. The side slope would be constructed at a slope of 3H:1V. The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program, but the backfill layer would not be maintained.

In the sideslope and shoal areas of RM0 to RM8.3, it is likely that additional, un-targeted contaminant inventory would remain in place. For this reason, it is assumed that an engineered cap would be placed in these areas. In areas of unacceptable erosion, as identified in Appendix G of the FFS (Malcolm Pirnie, Inc., 2007b), stone would be used as armor material. The thickness of the engineered cap would be monitored and maintained following implementation as part of the annual Post-Construction Monitoring Program.

Flood modeling as described in Appendix G of the FFS (Malcolm Pirnie, Inc., 2007b), has shown that pre-dredging prior to cap placement would reduce the total area flooded to below the acreage flooded under the base case. Therefore, pre-dredging in areas to be capped has been incorporated into Alternative 5.

The dredged material removed during implementation of Alternative 5 would be placed into a nearshore CDF. After the material is passively dewatered, it may either be removed from the CDF for thermal treatment (DMM Scenario B), or it may be permanently capped in place (DMM Scenario A).

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while MNR processes act to reduce the concentration of the remaining contamination until the RAOs are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained, and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of site conditions would be conducted at five-year intervals, as required by CERCLA.

A portrayal of Alternative 5 is shown on Figure 2.8-5, and the costs and schedule for Alternative 5 are summarized in Table 2.8-5. Alternative 5 involves the removal of approximately 6,148,000 cy of dredged material and the placement of approximately 2,453,000 cy of capping material, 95,000 cy of armor material, and 208,000 cy of mudflat reconstruction material.

Table 2.8-5: Summary of Costs and Construction Time for Alternative 5

Costs	DMM Scenario A	DMM Scenario B
Total Capital Costs:	$839,000,000	$839,000,000
Total DMM Costs:	$489,000,000	$814,000,000
Total O&M Costs:	$93,000,000	$96,000,000
Total Present Worth Costs (5 Percent Rate over 30 Years):	$1,421,000,000	$1,749,000,000
Construction Time:	7 years	7 years

Alternative 6 – Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine-Grained Sediment from Primary Inventory Zone and Primary Erosional Zone

A portrayal of Alternative 6 is identical to that of Alternative 5, with the exception that, in the Primary Erosional Zone and the Primary Inventory Zone, the depth of dredging is assumed to be the estimated depth of fine grained sediment plus an additional one foot to account for dredging accuracy.

After construction is completed, this alternative relies on institutional controls, such as fish consumption advisories and restrictions on activities that could compromise the integrity of the cap, while MNR processes act to reduce the concentration of the remaining contamination until the RAOs are achieved. A long-term monitoring program would be implemented to verify the integrity of the cap, ensure that the thickness of the cap is maintained, and verify that the river is responding with reduced contamination levels over the long term. If any portion of the cap became eroded, it would require replacement. A review of site conditions would be conducted at five-year intervals, as required by CERCLA.

A portrayal of Alternative 6 is shown on Figure 2.8-6, and the costs and schedule for Alternative 6 are summarized in Table 2.8-6. Alternative 6 involves the removal of approximately 7,010,000 cy of dredged material and the placement of approximately 2,368,000 cy of capping material, 49,000 cy of armor material, and 208,000 cy of mudflat reconstruction material.

Table 2.8-6: Summary of Costs and Construction Time for Alternative 6

Costs	DMM Scenario A	DMM Scenario B
Total Capital Costs:	$879,000,000	$879,000,000
Total DMM Costs:	$524,000,000	$849,000,000
Total O&M Costs:	$93,000,000	$96,000,000
Total Present Worth Costs (5 Percent Rate over 30 Years):	$1,496,000,000	$1,824,000,000
Construction Time:	8 years	8 years

2.8.1 Compliance of Monitored Natural Recovery with USEPA Policy

The MNR component of the active alternatives was developed in accordance with *Contaminated Sediment Remediation Guidance for Hazardous Waste Sites* (USEPA, 2005c). A detailed understanding of the natural processes that are affecting sediment and contaminants at the site was developed in the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c), and a tool to predict future effects of these natural processes was developed in the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b). Significant ongoing contaminant sources have been identified in the EMBM, and the USEPA plans to initiate work to identify and characterize sources of contamination located upstream of Dundee Dam (Malcolm Pirnie, Inc., 2007b). A detailed HHRA and ERA have been performed (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) to address ongoing risks and exposure control. Monitoring of natural processes and contaminant concentrations to assess natural recovery can be performed through sediment and biological tissue sampling programs.

The reduction of contaminant concentrations through MNR in the Lower Passaic River will rely on two major processes:

- Burial and/or mixing-in-place of contaminated sediment with cleaner sediment.

- Dispersion of particle-bound contaminants or diffusive or advective transport of contaminants to the water column.

Contaminant reduction through transformation processes (*e.g.*, biodegradation, abiotic transformations) and sorption or other binding processes will not be relied upon.

2.9 COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES

Nine criteria are used to address the CERCLA requirements for analysis of remedial alternatives. The first two criteria are threshold criteria that must be met by each alternative. The next five criteria are the primary balancing criteria upon which the analysis is based. The final two criteria, referred to as modifying criteria, are typically applied following the public comment period for the Proposed Plan to evaluate state and community acceptance. The following sections present a detailed analysis of the individual remedial alternatives in reference to the evaluation criteria and a comparative analysis to evaluate the relative performance of remedial alternatives in relation to each evaluation criterion. The comparative analysis of remedial alternatives is summarized in Table 2.9-1 (a summary of the detailed analysis) and Table 2.9-2 (a summary of quantitative estimates for each alternative).

2.9.1 Overall Protection of Human Health and the Environment

Based on the risk evaluations summarized in Section 2.6 "Summary of Site Risks," existing conditions present unacceptable risks to human health and the environment. The No Action alternative is not protective under this criterion. Active remediation of the Area of Focus reduces the COPC and COPEC concentrations in the surface sediments to within the background concentrations that are currently introduced to the Lower Passaic River from the Upper Passaic River, reduces the human health risk by 95 to 98 percent (fish versus crab consumption), and reduces the ecological hazard by 78 to 98 percent (species dependent), which meets the RAOs. Based on prediction of future surface concentrations generated using the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b), active remediation of the Area of Focus followed by MNR will achieve thresholds for 2,3,7,8-TCDD, which is responsible for about 65 percent of the risk, 40 years faster than it would be achieved by MNR alone. (Quantitative predictions presented are subject to the uncertainties in the EMBM and Risk Assessment, as described in Section 3.6 "Carefully Evaluate the Assumptions and Uncertainties Associated with Site Characterization Data and Site Models." However, inferences inherent in these evaluations have been derived from a thorough and comprehensive understanding of the site through the CSM, which was built upon detailed geochemical data evaluations and the assimilation of various data sources.) The reduction of other COPCs and COPECs is also achieved by active remediation of the Area of Focus. For this reason, the six active alternatives are considered protective of human health and the environment.

2.9.2 Compliance with ARARs

Each active remedial alternative would be designed and constructed in compliance with the ARARs identified, except those which may be waived by the Regional Administrator in accordance with CERCLA Section 121(d).

The active alternatives are comprised of the following seven elements:

- Pre-Construction Activities
- Construction and Operation of a Support Area
- Dredging
- Capping

- CDF Construction and Operation
- Thermal Treatment
- Wastewater Treatment and Discharge

Table 2.9-3 lists the ARARs and their statutory or regulatory citations for each of these seven elements. This table also presents the rationale for the parts of each element of the remediation process that will fall under each ARAR.

2.9.3 Long-Term Effectiveness and Permanence

2.9.3.1 Magnitude of Residual Risk

The overall risk reduction achieved by each alternative has been evaluated based on the future surface concentrations predicted by the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b). Over the time frame considered (30 years after remedial actions are complete), the active remedial alternatives reduce cancer risk for the combined child/adult receptor to 5×10^{-4} from fish consumption and to 4×10^{-4} from crab consumption. In addition, the non-cancer health HI for the adult receptor is reduced from 64 to 4.7 from fish consumption and from 86 to 3.5 from crab consumption. The non-cancer health HI for the child receptor is reduced from 99 to 22 from fish consumption and from 140 to 19 from crab consumption. The ecological hazards present at the site are reduced from 339 to 5.8 for the mink receptor and from 49 to 1.8 for the heron receptor (Malcolm Pirnie, Inc., 2007b). The risk reduction for each of the six active alternatives is equivalent at the level of precision achieved by the calculations presented in the EMBM, and no additional risk reduction is estimated to result from additional removal of contaminated sediment, as each alternative places a sand layer and achieves equivalent surface concentrations following active remediation.

In addition, all of the active remedial alternatives rely on institutional controls to maintain protectiveness following remedy construction, while natural recovery processes continue to reduce surface concentrations in the Area of Focus to reduce risks to within the risk range. Existing fish consumption advisories will remain in effect and will be gradually relaxed according to risk thresholds as sediment and fish tissue concentrations improve over the long-term. Fish consumption advisories have definite limitations, however. Although fish consumption advisories are currently in place for the Lower Passaic River, creel surveys of anglers along the river have found that a considerable proportion of the group continues to consume fish and crab above the "eat none" advisory; this consumption poses a risk to these residents. As an institutional control, coordination between the NJDEP and USEPA regarding the issuance of fish consumption advisories will be necessary. Also, it may be necessary to implement outreach programs to inform the community regarding the advisories. In addition to fish consumption advisories, long term institutional controls will include restrictions on dredging to create additional berths after the implementation of the Source Control Early Action, limitation on recreational use of the waterway, restrictions on private sediment disturbance activities, and dredging moratoriums.

Separate source control actions above Dundee Dam, when implemented, will also accelerate the time frame within which the active alternatives achieve risk ranges.

2.9.3.2 Adequacy and Reliability of Controls

Among the six remedial alternatives, there is not a great difference in the degree of reliability of controls achieved. The reliability of both dredging and engineered caps depends upon proper design and implementation, while the reliability of capping also depends on the consistency and sufficiency of future maintenance.

Alternative 1 relies exclusively on placement of a backfill layer to provide a measure of control in the event that residual contamination poses health risks. This alternative does not include an engineered cap, because the intent is for the contaminated fine-grained sediment to be removed with the assumption that the underlying less-contaminated sand material will not erode to any significant extent. The backfill layer is not intended to be maintained, in contrast to the engineered cap in Alternative 2 whose thickness is maintained in the long term in order to ensure protectiveness of contaminant inventory left underneath.

Alternatives 3, 4, 5, and 6 rely on varying combinations of backfill and engineered cap, depending on the amount of contaminated inventory left after dredging. Of these four alternatives, Alternative 3 proposes removing the most fine-grained sediment down to the underlying sandy layer, while Alternative 4 proposes leaving behind the most contaminant inventory, so that Alternative 3 relies most heavily on backfill and Alternative 4 relies most on engineered capping. Institutional controls would be required to ensure that engineered cap layers are not disturbed by human activities.

In all active alternatives, the use of a CDF for storage or final disposal, if constructed properly (*e.g.*, with low permeability barriers and with effluent controls) is considered to be adequate and reliable based on the preliminary identification of potential sites and the use of similar facilities in other projects.

Established thermal destruction facilities have sufficient prior experience with treatment of hazardous materials and disposal of treatment residuals to predict a high level of reliability. Newly constructed facilities would require a prove-out period to demonstrate ability to reduce contaminant concentrations to acceptable levels reliably and to ensure air emissions are within acceptable ranges.

All active remedial alternatives include the use of long term institutional controls, each of which has specific limitations. For instance, the implementation of fish consumption advisories along the Lower Passaic River may require community outreach programs to inform the community regarding the advisories. In addition, restrictions on dredging to create additional berth areas would need to be conducted such that resuspension of contaminated sediments in the berth area and subsequent recontamination of adjacent capped areas is minimized or avoided. Replacement of the engineered cap in the new berth area would also be required.

2.9.4 Reduction of Toxicity, Mobility, or Volume through Treatment

2.9.4.1 Treatment Processes Used and Materials Treated

Among the six remedial alternatives, the treatment processes used on Lower Passaic River sediments do not vary.

The extent to which each treatment process is used varies based on the mass and volume of sediment removal. For example, Alternative 2 removes the least amount of sediment, while Alternative 1 removes the most. After removal, thermal treatment of dredged sediment, if used, will irreversibly destroy organic contaminants in the treated sediment, while non-volatile metals will be fused and bound into the residual matrix. Volatile metals will be released from the sediment matrix and captured during control of the off-gas emissions. In addition, water treatment associated with dewatering operations will reduce the toxicity, mobility, and volume of contaminants present in process water.

2.9.4.2 Amount of Hazardous Material Destroyed or Treated

Among the six remedial alternatives, the amount of contaminated Lower Passaic River sediment removed and treated varies based on the depth and extent of dredging. The estimates of removal volume are presented in Table 2.9-2.

2.9.4.3 Degree of Expected Reductions in Toxicity, Mobility, and Volume

The six remedial alternatives vary slightly in their expected degrees of reduction in toxicity, mobility, and volume.

Alternative 1 involves removal of all fine-grained sediment. Alternatives 2-6 involve some removal of sediments before placement of a cap and armor. Each of these alternatives would, to some degree, reduce the volume of contaminated sediment in the Lower Passaic River by removal and subsequent treatment, if DMM Scenario B were selected. The degree of volume reduction varies based on the depth and extent of dredging. The type of treatment specified for the removed sediment dictates the degree of reductions in toxicity, mobility, and volume. Thermal treatment would be expected to achieve approximately 99.9999 percent reduction in organic contaminants. Thermal treatment residuals could be disposed in a secure landfill or CDF. Material disposed in a CDF would not be treated prior to placement, but the mobility of contaminants in the material would be reduced. Disposal in a CDF would not satisfy the CERCLA statutory preference for treatment.

Alternatives 2-6 rely on capping to sequester contaminated sediments. The cap reduces the mobility of contaminants, thus reducing the transport to Newark Bay and the New York-New Jersey Harbor Estuary. Capping does not satisfy the CERCLA statutory preference for treatment. In addition, there is no reduction in the toxicity or volume of the contaminants under the cap.

2.9.4.4 Type and Quantity of Residuals Remaining after Treatment

The six remedial alternatives vary in the quantity of residuals generated based on the degree of sediment removal.

If sediment removal is followed by dewatering and water treatment, residuals such as flocculation sludge and filter sands would be generated. The quantities of these residuals would depend upon the sediment volumes that are removed. In addition, alternatives involving sediment dewatering may generate debris such as rocks, wood, and a variety of navigational and urban refuse that would be unable to pass through the dewatering treatment train; these materials would need to be managed as waste or recycled.

Thermal destruction would irreversibly destroy organic contaminants in the treated sediment. Thermal treatment residuals could be disposed in a secure landfill or CDF or be used beneficially as a product.

2.9.5 Short-Term Effectiveness

The six remedial alternatives vary slightly in short term effectiveness, as discussed below.

2.9.5.1 Protection of the Community during Remedial Action

Implementation of any active remedial alternative would result in impacts to the community (*e.g.*, noise, lights, and traffic) and could potentially require the processing, storage, transportation, and disposal of contaminated sediment near the Lower Passaic River. Engineering controls would be in place to reduce the potential for exposure of the community to contaminants. The development of a community health and safety plan would be required prior to the implementation of the Source Control Early Action. Community outreach programs would be performed to understand the communities' health concerns during the project, and coordination with community members would be undertaken to identify actions needed to protect their health and safety. In addition, sampling during dredging operations would be conducted that may be used to monitor the potential recontamination of the river.

The placement of cap materials would likely result in a lesser degree of resuspension than dredging of contaminated sediment (USEPA, 2005c). The overall duration during which the community would be impacted is greater for alternatives which remove a greater volume of material (*e.g.*, Alternative 1 would impact the community for a longer period of time than Alternative 2).

2.9.5.2 Protection of Workers during Remedial Action

The implementation of any active remedial alternative would potentially expose workers to contaminated sediment; however, dredging activities could result in a higher likelihood of exposure via direct contact, ingestion, and inhalation of contaminants in sediments and surface water than would placement of capping materials. The overall time during which workers would require protection is greater for alternatives which remove a greater volume of material. A worker health and safety plan would be required for the implementation of any active remedial alternative.

2.9.5.3 Environmental Impacts

Alternatives which involve dredging of larger quantities of material require longer project durations, and potentially present incrementally greater potential for increased exposure of the community to dredged material. This potential for exposure can be reduced with the proper engineering controls, health and safety approaches, and design considerations.

In addition, the short term environmental impacts associated with resuspension of contaminated sediment would likely be incrementally greater for alternatives involving greater volumes of removal.

The existing habitat present in the Area of Focus would be impacted by any active remediation alternative. In addition, resuspension associated with cap placement or dredging activities could result in the transport of contaminated sediments and subsequent impact to adjacent areas. The placement of cap materials would likely result in a lesser degree of contaminant resuspension than dredging of contaminated sediment.

All remedial alternatives would involve the placement of clean material over existing sediment and reconstruction of mudflat areas impacted by remedial activities. In areas where armor is placed, benthic recolonization could occur, provided that silt or other benthic habitat material is subsequently deposited via natural processes. The construction of a CDF would constitute a permanent impact to habitat, and would require mitigation.

2.9.5.4 Time until Remedial Action Objectives are Achieved

The six remedial alternatives vary slightly in duration of implementation, as each alternative contains similar components including pre-design activities, design, mobilization, dredging, capping or backfilling, and demobilization. Following implementation, trends in surface sediment concentrations for each alternative are also comparable, as the post-implementation surface sediment concentrations achieved by each alternative are equivalent. These trends may be influenced by the depositional conditions achieved by each alternative.

Based on the relative contributions of the various sources of contamination considered in the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b) and historical trends in sediment cores, post-remediation COPC and COPEC concentrations were calculated for the various remedial alternatives, based on the fact that remediation will reduce the resuspension flux of legacy sediments. Sediment resuspension as a source will be controlled by active remediation because each remedial alternative includes the placement of sand material in the lower eight miles of the river. This sand material will restrict the erosion and mixing of older, more contaminated sediments with the Lower Passaic River surface sediment. By controlling resuspension, future surface sediment concentrations were calculated for MNR (*i.e.*, no change in the resuspension source) and the active remedial alternatives. Refer to the EMBM for further detail on these calculations (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b).

Given the natural processes that are occurring in the river, the concentrations of most COPCs and COPECs will decline over time regardless of the method chosen for remediation. However, the EMBM concluded that active remediation has a significant effect on how quickly the recovery will occur as compared to MNR alone. For example, active remediation of the Area of Focus followed by MNR will achieve any threshold for 2,3,7,8-TCDD, which is responsible for about 65 percent of the risk, 40 years faster than it would be achieved by MNR alone. The reduction of other COPCs and COPECs is also accelerated by active remediation of the Area of Focus, except for chemicals (such as PAH) that have continuing sources external to the river. Table 2.9-4 gives the reduction of time in years for each COPC and COPEC for active remediation of the Area of Focus as compared to MNR (for any contamination threshold).

Table 2.9-4: Time Difference Between MNR Scenario and Area of Focus Scenario (Malcolm Pirnie, Inc., 2007b)

Analyte	Time Difference (Years)
Mercury	10
Lead	5
Copper	5
Total Chlordane	-
DDE	15
DDD	15
DDT	15
Total DDT	15
Dieldrin	-
2,3,7,8-TCDD	40
PCDD/F TEQ	40
Total PCB	10
PCB TEQ Mammal	10
PCB TEQ Bird	10
PCB TEQ Fish	10
Total TEQ Mammal	40

Analyte	Time Difference (Years)
Total TEQ Bird	25
Total TEQ Fish	40
LMW PAH	-
HMW PAH	-

The symbol (-) represents no time difference.

The 17-mile Study will evaluate remaining threats to human health and the environment in the Study Area and the timeframe to achieve RAOs through a fate, transport, and bioaccumulation model that is currently in development and not available for this Briefing Package.

2.9.6 Implementability

2.9.6.1 Technical Feasibility

Alternatives 1-6 are all technically feasible. However, a major consideration in evaluating the feasibility of each alternative after implementation is the impact on flooding caused by changes in the bathymetry and bottom roughness of the river. Hydrodynamic modeling results presented in Appendix G of the FFS (Malcolm Pirnie, Inc., 2007b) indicate that Alternatives 2 and 4 have considerable flooding impacts; implementation of either alternative would increase flooding by 93 and 24 acres, respectively, beyond the amount predicted by modeling of existing conditions. Conversely, implementation of Alternative 5 would result in a slight reduction (by 17 acres) in flooding impact compared to existing conditions. Alternatives 1, 3, and 6 were not modeled, but are expected to show reductions similar to or greater than those predicted by modeling of Alternative 5, as similar sediment surface conditions but greater water depths are achieved by implementation of these alternatives.

2.9.6.2 Availability of Services and Materials

Each remedial alternative utilizes both dredging and capping or backfilling. Dredging and capping are both well developed technologies, and adequate, reliable, and available technology can be procured; there are no anticipated challenges to implementability.

Initial efforts have identified several potential land-based borrow sources in New Jersey collectively capable of supplying suitable capping material for the implementation of active alternatives; however, the capacity of individual sources has not been determined. Additionally, under the New York Harbor Deepening Program, several million cubic yards of sand will be removed from federal navigation channels between 2008 and 2011; although modeling results presented in Appendix G of the FFS (Malcolm Pirnie, Inc., 2007b) show that a cap cannot be constructed of this sand alone, this sand could be suitable for use in a filter layer or as backfill material. Furthermore, substantial quantities of rock will be removed from federal navigation channels, and could, if processed, be used as armor material. Significant cost savings would be realized if remediation activities could be coordinated with regional dredging programs (*e.g.*, utilization of sand or rock from the Harbor Deepening Program) to beneficially use this dredged material for backfill of dredged areas or construction of an engineered cap.

A preliminary review of the environs of the Lower Passaic River and Newark Bay suggests there are various nearshore areas amenable to the development of a CDF of sufficient size to accommodate the material to be removed from the Lower Passaic River as a consequence of any alternative. A thorough siting study would be required during the design phase.

Some portion of the contaminated sediment in the Lower Passaic River could be treated via thermal destruction methods. This feasibility analysis has identified potential thermal treatment options and vendors, and has identified no technical issues that would prevent construction of a new onsite facility.

2.9.6.3 Administrative Feasibility

The execution of any remedial activity in the Lower Passaic River would require significant coordination with and among federal, state, and local agencies. Alternatives 2-6, those involving capping, would require that issues pertaining to navigation be resolved prior to design of cap elevation, and that the creation of future habitat be discussed. Alternatives which incorporate greater quantities of dredging could potentially require incrementally more coordination due to the greater impact that dredged material management activities would have on the surrounding area and the need to identify suitable locations for a CDF for processing, storage, transportation, treatment, and disposal of dredged material.

2.9.7 Cost

The total cost for each alternative has been estimated based on capital costs as well as O&M costs. The six remedial alternatives range in cost from $0.9 billion to $2.3 billion (Malcolm Pirnie, Inc., 2007b).

2.9.7.1 Capital Costs

Capital costs have been estimated for activities pertaining to pre-construction investigations and design, mobilization/demobilization, site preparation, dredging and/or capping, and dredged material management. While capital costs for these activities vary predictably based on the extent of remediation conducted, the major drivers of capital cost are dredging and dredged material management. Alternatives which utilize dredging to remove a given volume of contaminated sediment are significantly more costly than alternatives which sequester the same volume of contaminated sediment by means of an engineered cap.

2.9.7.2 Operations and Maintenance Costs

Alternatives which employ an engineered cap over a greater area require more significant operations and maintenance costs. Monitoring of cap thickness and replenishment could be required, to some extent, in perpetuity. The extent of monitoring and maintenance, and therefore the total present worth of O&M costs, would depend on the time needed to verify the long term stability of the cap and the absence of significant contaminant fluxes through the cap. The cost estimates generated during this feasibility analysis have been based on a maintenance period of thirty years; however, a longer timeframe may apply for cap maintenance.

Finally, while operations and maintenance costs are higher for alternatives which utilize an engineered cap, the capital costs associated with dredged material management drive the total cost of alternatives which involve greater quantities of dredging. Alternatives involving capping achieve the same mass remediation and risk reduction as alternatives involving greater quantities of dredging for significantly lower total cost; however, the reliability of capping depends on the consistency and sufficiency of future maintenance activities.

2.9.8 State Agency Acceptance

State acceptance is not addressed in this document, but will be addressed in the ROD. It is important to note that NJDOT is the WRDA non-federal sponsor and NJDEP in a Trustee for the site; both are agency partners participating in the Study. As such, input from the State of New Jersey was sought and considered throughout the development of the FFS.

2.9.9 Community Acceptance

Community acceptance of the Source Control Early Action will be assessed in the ROD once public comments on the proposed plan have been received. Input from the public and interested stakeholders, including the partner agencies, was sought and considered throughout the development of the FFS. This occurred through various technical workgroup sessions organized and hosted by the USEPA, through publication of information on the project website (www.ourPassaic.org), publication of information to interested members of the public in the form of ListServ notices, and other community involvement activities. A municipalities workshop was held in April 2007 to share project information and address community-specific concerns. Municipalities that participated in the workshop include Bayonne, Bloomfield, Clifton, Elizabeth, Garfield, Harrison, Newark, Nutley, and Rutherford. See Section 3.2 "Involve the Community Early and Often" for more information on community involvement activities. Another meeting was held in July 2007 to brief the municipalities of the lower eight miles on the Source Control Early Action FFS. The towns of Kearny and Harrison, the City of Newark, and Hudson County participated in this meeting.

2.10 PRINCIPAL THREAT WASTE

Not applicable.

2.11 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Chemical-specific, location-specific, and action-specific ARARs and "To Be Considered" Information (TBCs) are considered in the development and evaluation of remedial alternatives (Malcolm Pirnie, Inc., 2007b). When an alternative is selected, it must be able to fulfill the requirements of all ARARs (or a waiver must be justified). The ARARs and TBCs presented in this section apply to all of the remedial alternatives.

Table 2.9-3 provides a compilation of the ARARs identified for the FFS in consultation with the partner agencies, including statutory or regulatory citations for each ARAR. The ARARs are listed according to their applicability to each the seven elements of the Source Control Early Action (see Section 2.9.2 “Compliance with ARARs”).

No ARARs were identified as drivers for the remedial alternatives. ARARs drive the methods by which the remediation will be performed, but they do not drive the need for the remediation itself.

2.11.1 Chemical-Specific ARARs and TBCs

Chemical-specific ARARs and TBCs define concentration limits or other chemical levels for environmental media. Based on the RAOs for the Source Control Early Action FFS, only requirements for sediment are considered here. There are no ARARs for sediments.

A broad universe of potential chemical-specific TBCs was initially identified from criteria developed by other USEPA regions and a variety of other agencies (Appendix B of the FFS; Malcolm Pirnie, Inc., 2007b). PRGs were developed for the FFS; these PRGs, while not ARARs, are concentration limits that have been developed specifically for the Source Control Early Action based on site-specific RBCs and background concentrations. They are thus considered to be more appropriate benchmarks for Early Action at the site than any of the initially identified chemical-specific TBCs. As a result, all of the potential chemical-specific TBCs were screened from consideration as viable criteria for the Source Control Early Action.

2.11.2 Location-Specific ARARs and TBCs

The following location-specific ARARs were identified for the FFS:

- Endangered Species Act, 16 United States Code (U.S.C.) §1536; 50 Code of Federal Regulations (CFR) §402 Subpart B: Broad protection is provided for species of fish, wildlife, and plants that are listed as threatened or endangered in the United States or elsewhere.

- Federal Consistency Determination, 15 CFR § 930.36: The Federal Consistency Determination requires that federal agencies review their activities to determine whether such activities will be undertaken in a manner consistent to the maximum extent practicable with the enforceable policies of approved management programs.

- Freshwater Wetlands Protection Act Rules, New Jersey Administrative Code (N.J.A.C.) 7:7A-4.3: The Act regulates activities in freshwater wetlands, such as excavation, drainage, discharge of material, driving pilings, placing obstructions to flow, and destruction of plant life. The process for delineating a wetland and determining the width of the transition zone is specified, and wetland mitigation requirements are presented.

- National Historic Preservation Act (NHPA), 16 U.S.C. §470 et seq.; 36 CFR. Part 800: The NHPA requires consultation to identify historic properties potentially affected by federal activities and to assess the effects and to seek ways to avoid, minimize or mitigate any adverse impacts to those identified properties.

- Soil Erosion and Sediment Control Act regulations, N.J.A.C. 7:13-3.3: These regulations require controls for soil erosion and sediment prior to commencing any land development projects.

- Flood Hazard Control Act, New Jersey Statues Annotated (N.J.S.A.) 15:16A-50, et seq.: These regulations cover stream encroachment activities and development in floodways and flood fringes. Designs must prevent obstruction of flow or change in flow velocity in the case of a flood. Evaluations are ongoing to determine the applicability of these regulations.

The following location-specific TBC was identified for the FFS:

- NJDEP Soil Cleanup Criteria. [Contaminant Values for Residential Direct Contact Soil Cleanup Criteria, Non- Residential Direct Contact Soil Cleanup Criteria, and Impact to Ground Water Soil Cleanup Criteria; last revised May 12, 1999 (Note that NJDEP proposed new Soil Cleanup Criteria in May 2007; the final rule is planned to be promulgated after a public comment period ending July 27, 2007.)] The NJDEP soil cleanup criteria will be utilized for determining the appropriateness of using dredged sediments, or treated dredged sediments, for other beneficial land application uses within the State of New Jersey.

2.11.3 Action-Specific ARARs and TBCs

The following action-specific ARARs are identified for the FFS:

- Rivers and Harbors Act, 33 U.S.C. § 403: Activities that could impede navigation and commerce are prohibited without authorization from the Secretary of the Army. Such activities include obstruction or alteration of any navigable waterway, building of bulkheads outside harbor lines and any excavation or fill in navigable waters. In accordance with CERCLA Section 121(e)(1), no federal, state, or local permits are required for remedial actions that are conducted entirely on site, although remedial actions must comply with the substantive requirements of the Rivers and Harbors Act.

- Section 404 of the Clean Water Act (CWA), 40 CFR Parts 321, 322, and 323: The CWA includes requirements for the discharge of dredged or fill material into navigable waters of the United States. The Act also regulates the construction of any structure in navigable waters.

- RCRA, 40 CFR. § 261, 262, 264, 265, and 268: Dredged material may be subject to RCRA regulations if it contains a listed waste, or if it displays a hazardous waste characteristic based on the TCLP test. RCRA regulations may potentially be ARARs for the storage, treatment, and disposal of dredged material unless an exemption applies. If dredged material is removed but replaced in water within the Area of Contamination, which for this FFS includes the Lower Passaic River, Newark Bay and areal extent of contamination, RCRA land disposal regulations are not triggered.

- Toxic Substances Control Act (TSCA), 40 CFR. § 761: TSCA regulates PCBs from manufacture to disposal. Remediation of sediments with PCB concentrations greater than 50 milligrams per kilogram of sediment or part per million is considered PCB waste remediation and is controlled under TSCA.

- Hazardous Materials Transportation Act, 49 CFR. § 107, 171, 172 and potentially 174, 176, or 177: United States Department of Transportation rules apply to the transportation of hazardous materials, and include the procedures for the packaging, labeling, manifesting, and transporting of hazardous materials.

- Stormwater Management Rules, N.J.A.C. 7:8-2.2 and Subchapter 5: These regulations establish the design and performance standards for stormwater management measures.

- Water Quality Certification, Section 401 of the CWA, 33 U.S.C § 1341: The CWA requires that applications for permits and licenses for any activity resulting in a discharge to navigable water include certification that the discharge will comply with applicable water quality and effluent standards. In accordance with

CERCLA Section 121(e)(1), no federal, state, or local permits are required for remedial actions that are conducted entirely on site, although remedial actions must comply with the substantive requirements of CWA Section 401.

- NJPDES Rules, N.J.A.C. 7:14A, (Subchapters 4.4, 5.3, 6.2, 11.2, 12.2, 13, 21.2 and Appendix B of chapter 12): This chapter regulates the direct and indirect discharge of pollutants to the surface water and ground water of New Jersey. It presents a list of effluent standards for site remediation projects, and includes rules for land application permits, residual transfer stations, and stormwater discharge information. In accordance with CERCLA Section 121(e)(1), no federal, state, or local permits are required for remedial actions that are conducted entirely on site, although remedial actions must comply with the substantive requirements of the NJPDES rules.

- New Jersey Technical Requirements for Site Remediation, N.J.A.C 7:26E-1.13, -2.1, -2.2, -3.4, -3.8, -3.11, -4.5 and -4.7: These regulations identify the minimum technical requirements that must be followed in the investigation and remediation of any contaminated sites in New Jersey. Both numeric and narrative standards for remediation of groundwater and surface water are listed.

- Federal/State Pretreatment Standards, 40 CFR. § 403, and more stringent requirements enacted by State or local law: These standards provide pretreatment criteria that waste streams must meet prior to discharge to a publicly owned treatment works (POTW).

- National Ambient Air Quality Standards (40 CFR. § 50): The Clean Air Act requires USEPA to set standards for pollutants considered harmful to public health and the environment. Standards are established for six primary and secondary pollutants.

- New Jersey Air Pollution Control Rules, N.J.A.C. 7:27: The chapter governs emissions that introduce contaminants into the ambient atmosphere for a variety of substances and from a variety of sources.

2.12 TECHNICAL AND POLICY ISSUES

Technical and policy issues associated with the selection and implementation of the Source Control Early Action are discussed below.

2.12.1 Dioxin Toxicity Values

Issues related to dioxin toxicity values were discussed in Section 2.6.1.2 "Types and Characteristics of Contaminants of Potential Concern."

2.12.2 Determining Future Navigational Requirements

The remedial alternatives presented in the FFS (Malcolm Pirnie, Inc., 2007b) incorporate three options for the reconstruction of the navigation channel in the Lower Passaic River. Alternative 3 allows for the reconstruction of the federally authorized navigation channel, which would be the deepest channel compared to those incorporated in the other alternatives. Alternative 4 allows for the shallowest channel, the reconstruction of the navigation channel to accommodate current usage as described in USACE's Navigation Analysis (Appendix F of the FFS; Malcolm Pirnie, Inc., 2007b). Alternatives 5 and 6 incorporate the reconstruction of the navigation channel to accommodate future use, which is discussed in a memorandum prepared by the NJDOT (Appendix F of the FFS; Malcolm Pirnie, Inc., 2007b). Depths of the federally authorized navigation channel and recommended minimum depths to accommodate current and future use are discussed in Sections 2.5.2.1 "Current Federally Authorized and Constructed Navigation Channel," 2.5.2.2 "Navigational Channel Dimensions to Accommodate Current Surface Water

Uses," and 2.5.2.3 "Navigational Channel Depths to Accommodate Reasonably Anticipated Future Surface Water Uses," respectively.

Determining which navigational use scenario will meet the needs of federal and state agencies as well as local governments and communities in the Study Area represents a policy issue with respect to the implementation of the Source Control Early Action. predecis ional -

predecisional -deliberative; attorney-client communication

2.12.3 CDF Siting

predecisional -deliberative

predecisional -deliberative Construction of a CDF would require e CDF could be used for storage and passive dewatering of dredged sediment. A leachate collection system could be constructed to collect and channel effluent to a treatment system. As a final use, the dewatered sediment in the CDF could be removed for thermal treatment, or it could be permanently capped to create land for a beneficial use such as a park or development. One advantage of using a nearshore CDF for temporary storage is that a smaller thermal treatment plant could be constructed at a lower capital cost and sediment could be treated over a longer time.

Two DMM scenarios incorporating nearshore CDF disposal are associated with the Source Control Early Action. DMM Scenario A assumes that all dredged material would be permanently disposed of in a CDF. DMM Scenario B assumes that all dredged material would initially be placed in a CDF, but the volume stored above the original mudline grade (prior to excavation within the CDF footprint), would be dewatered and treated by an onsite thermal treatment facility. The volume to be thermally treated under

Scenario B is up to approximately 1.7 million cy (*in-situ*). If necessary at a particular location when selected, excavation below the mudline (within the footprint of the CDF) would be performed to provide the required capacity.

Technical issues related to the siting of a CDF include the following:

- The need for an extensive data collection program to identify and evaluate potential sites for the CDF; the program would include evaluations of site geology, evaluations of local community needs, and other relevant analyses.

- The design and construction of the CDF, including containment measures.

- The potential design and construction of a thermal treatment facility.

Policy issues related to the siting of a CDF include the following:

- Determining whether local communities in the selected area for the CDF prefer the construction of a thermal treatment facility or the development of a park or other beneficial use at the CDF site at project completion.

- The role of recent precedent and flexibility for remedial purposes in determining State acceptance of a CDF or thermal treatment facility in the region.

The presence of the Newark Bay CDF[6] near Elizabeth Channel demonstrates that the option of using a CDF in New York Harbor is implementable. The Newark Bay CDF was constructed in 1997 for sediments generated as a result of navigational dredging;

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[6] Note that although it is referred to as a CDF, the Newark Bay facility is technically a Confined Aquatic Disposal (CAD) cell as defined in this document. CAD involves subaqueous covering or capping of dredged material, whether simply placed on the bottom or deposited in depressions or excavated pits.

however, recent usage has been limited to emergency projects or projects with a demonstrated hardship (*i.e.*, other cost-feasible options are not available).

2.13 COST INFORMATION

The total cost for each alternative has been estimated based on capital costs, dredged material management costs, and O&M costs, and are presented in Table 2.13-1. The actual costs will vary depending on the specifications contained in the detailed remedial design. Further, the actual costs will also vary because the cost estimates provided are developed conservatively and have an accuracy of +50 percent to -30 percent, in compliance with USEPA guidance (USEPA, 1988).

Table 2.13-1: Cost Estimates for Remedial Alternatives

Alternative	DMM Scenario	Total Capital Costs	Total DMM Costs	Annual O&M Costs	Total O&M Costs	Total Present Worth Costs
Alternative 1: Removal of Fine-Grained Sediment from Area of Focus	A	$1,092,000,000	$763,000,000	$5,950,000	$91,000,000	$1,947,000,000
	B	$1,092,000,000	$1,085,000,000	$6,160, 000	$95,000,000	$2,272,000,000
Alternative 2: Engineered Capping of Area of Focus	A	$537,000,000	$230,000,000	$6,260, 000	$96,000,000	$863,000,000
	B	$537,000,000	$477,000,000	$6,280, 000	$97,000,000	$1,111,000,000
Alternative 3: Engineered Capping of Area of Focus Following Remediation of Federally Authorized Navigation Channel	A	$901,000,000	$522,000,000	$6,120, 000	$94,000,000	$1,518,000,000
	B	$901,000,000	$847,000,000	$6,280, 000	$97,000,000	$1,845,000,000
Alternative 4: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Current Usage	A	$754,000,000	$418,000,000	$6,160, 000	$95,000,000	$1,267,000,000
	B	$754,000,000	$744,000,000	$6,330, 000	$97,000,000	$1,596,000,000
Alternative 5: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage	A	$839,000,000	$489,000,000	$6,060, 000	$93,000,000	$1,421,000,000
	B	$839,000,000	$814,000,000	$6,230, 000	$96,000,000	$1,749,000,000
Alternative 6: Engineered Capping of Area of Focus Following Construction of Navigation Channel to Accommodate Future Usage and Removal of Fine-Grained Sediment from Primary Inventory Zone and Primary Erosional Zone	A	$879,000,000	$524,000,000	$6,050, 000	$93,000,000	$1,496,000,000
	B	$879,000,000	$849,000,000	$6,210, 000	$96,000,000	$1,824,000,000

2.13.1 Capital Costs

Capital costs have been estimated for pre-construction activities (includes investigation and design), mobilization/demobilization, dredging (not including dredged material management), and backfilling or capping. The capital costs also include an additional 8 percent of the cost of field activities for construction management services and an additional 20 percent for contingency. The major driver of capital costs is dredging. For a given volume, alternatives which utilize dredging are significantly more costly than alternatives which sequester it by means of an engineered cap.

2.13.2 Dredged Material Management Costs

DMM costs are considered for two DMM scenarios incorporating nearshore CDF. DMM Scenario A assumes that all dredged material would be permanently disposed of in a CDF, while DMM Scenario B assumes that the volume stored above the original mudline grade would be dewatered and treated by an onsite thermal treatment facility.

DMM costs have been estimated for site characterization, starter cell construction, sub-grade cell construction, CDF construction (includes CDF operation and closing costs), and on-site thermal treatment. The DMM costs also include an additional 8 percent of the cost of field activities for construction management services and an additional 20 percent for contingency. The major cost drivers for DMM costs are the sub-grade cell construction, the treatment of water within the CDF and from sediment dewatering operations, mechanical sediment dewatering, and on-site thermal treatment. Alternatives with smaller dredging volumes are less costly than alternatives with higher dredging volumes since excavation below the mudline is not as deep. Also, DMM Scenario B is significantly more costly than DMM Scenario A, since no thermal treatment is required in DMM Scenario A.

2.13.3 Operations and Maintenance Costs

Annual O&M costs have been estimated for bathymetric surveys, surface sediment, water column and groundwater sampling and analysis, biological monitoring, habitat recolonization surveys, cap maintenance, and community outreach. The major cost drivers are surface sediment sampling and analysis, biological monitoring and cap maintenance. While surface sediment sampling and analysis and biological monitoring costs are high, they are equal for all alternatives; however, O&M costs due to cap maintenance vary from one alternative to another. Alternatives which employ an engineered cap over a greater area require more significant O&M costs. Based on USEPA guidance, costs are included for a period of thirty years of monitoring for each alternative (USEPA, 1988); however, a longer timeframe may apply for cap maintenance. The present-worth of the annual O&M costs (total O&M costs) were calculated using a discount rate of 5 percent and a 30-year time interval.

Finally, while O&M costs are higher for alternatives which utilize an engineered cap, the DMM costs drive the total cost of alternatives which involve greater quantities of dredging. Alternatives involving capping achieve the same mass remediation and risk reduction as alternatives involving greater quantities of dredging for significantly lower total cost.

Because these alternatives would result in some contaminants remaining on-site above levels that allow for unrestricted use and unlimited exposure, CERCLA requires that the site be reviewed at least once every five years. If justified by the review, additional remedial actions may be implemented to remove, treat, or contain the contaminated sediments.

2.14 LETTERS FROM STAKEHOLDERS AND STATE

To be addressed.

3.0 CSTAG CONSIDERATION MEMORANDUM

As a Tier 2 site, remedy selection rationale for the Lower Passaic River must be reviewed by the Contaminated Sediments Technical Advisory Group (CSTAG). This section presents an evaluation of the Source Control Early Action as required for CSTAG consideration using the 11 Risk Management Principles identified by USEPA in OSWER Directive 9285.6-08 (USEPA, 2002b), which is also included as Appendix A of the Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA, 2005). Each subsection below provides a discussion addressing consistency of the remedy selection with one of the 11 principles, presented in the order they are considered in the Directive.

3.1 CONTROL SOURCES EARLY

During the course of the Lower Passaic River Restoration Project, the sediments of the lower eight miles of the river were identified as a major source of contamination to the rest of the lower river as well as Newark Bay and the New York-New Jersey Harbor Estuary (Appendix D of the FFS, Malcolm Pirnie, Inc., 2007b). Therefore, the FFS was undertaken to evaluate a range of remedial alternatives that might be implemented as an early action to control that source. The Source Control Early Action will address some or all of the contaminated sediments in the lower eight miles of the Passaic River, in order to reduce risks to human health and the environment. The Source Control Early Action, which will be a final action for the sediments in the lower eight miles, is intended to take place in the near term, while the comprehensive 17-mile study is ongoing.

Remediation of the Area of Focus through the Source Control Early Action will reduce the COPC and COPEC concentrations in the surface sediments over the long term to the background concentrations that are introduced to the Lower Passaic River from the Upper

Passaic River. Active remediation is also predicted to reduce the human health risk by 95 to 98 percent (fish versus crab consumption), the human health non-cancer HI by 93 to 96 percent (fish versus crab consumption) for the adult receptor and 78 to 86 percent (fish versus crab consumption) for the child receptor, and the ecological hazard by 78 to 98 percent (species dependent), which meets the RAOs. It is important to note that regardless of the PRG or risk levels that need to be achieved, remediating the Area of Focus achieves clean-up of 2,3,7,8-TCDD, which is responsible for 65 percent of the human health cancer risk, 40 years faster than it would be achieved by MNR alone. The reduction of other COPCs and COPECs is also accelerated by the remediation of the Area of Focus. For these reasons, all active alternatives were developed to remediate the Area of Focus, which encompasses the fine-grained sediments of the lower eight miles in their entirety. It is important to note that a discrete action would be incapable of effecting substantial improvement, as legacy sediments in the entire lower eight miles are actively mixing and acting as an ongoing source of contamination.

Other sources of dioxin contamination to the Lower Passaic River, including the Upper Passaic River (located above the Dundee Dam), major tributaries (including Saddle River, Second River, and Third River), CSO/SWOs, and Newark Bay are relatively small contributors of particle-bound contamination when compared with the resuspension of sediment within the Lower Passaic River itself. The Upper Passaic River is the dominant source of PAH compounds to the Lower Passaic River, resuspension of legacy sediments and the Upper Passaic River contribute roughly equal proportions of PCBs to the river, the combination of resuspension and the Upper Passaic River account for the majority of the DDE and mercury contaminant burdens to the river, and the mass balance for lead indicates roughly equal contaminant contributions from all five sources (resuspension, Upper Passaic River, major tributaries, CSO/SWOs, and Newark Bay). The USEPA plans to initiate work to identify and characterize contamination entering the Lower Passaic River from the Upper Passaic River (Malcolm Pirnie, Inc., 2007b). Because Newark Bay receives particle-bound contamination from a variety of sources, including the Lower Passaic River, the implementation of the Source Control Early Action will effect a gradual decrease in contaminant concentrations in Newark Bay.

Because of the contaminant load from the Upper Passaic River, any remedial effort within the Lower Passaic River can only be expected to meet the risk-based PRGs once the load from above the Dundee Dam also meets the PRGs. The load from the Upper Passaic River can be considered a baseline that represents the maximum concentration that would be expected in the Lower Passaic River (dilution from other less contaminated sediment sources would cause the concentrations in the Lower Passaic River to be less than what is contributed over the Dundee Dam).

The Source Control Early Action is an effort specifically designed to control contamination sources early. Remediation of the Area of Focus is being conducted prior to the Remedial Investigation/Feasibility Study for entire 17-mile Study Area in order to more quickly reduce a major source of contamination to the Lower Passaic River (*i.e.*, the resuspension of legacy sediments). The EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc., 2007b) identified the resuspension of legacy sediments as a large contributor of contamination concentrations for several COPCs and COPECs; the remediation of legacy sediments would significantly reduce contaminant concentrations in the Lower Passaic River as well as the contaminant loading to Newark Bay and the remainder of the Hudson-Raritan Estuary.

3.2 INVOLVE THE COMMUNITY EARLY AND OFTEN

Efforts to involve local communities along the 17-mile stretch of the Passaic River have been numerous and ongoing. Many of these efforts were presented in the combined Community Involvement Plan for the Lower Passaic River Restoration Project and the Newark Bay Study (Malcolm Pirnie, Inc., 2006a), and others have extended beyond specific elements of this plan.

In 2004, approximately 50 community interviews were conducted with local non-governmental organizations (*e.g.*, Passaic River Coalition, Clean Ocean Action, Ironbound Community Corporation), many of which represented the views of thousands of local and regional individuals in their respective organizations, and individuals across a diversity of interests representing different locations in the region, including Newark, Rutherford, Clifton, Keyport, and Sandy Hook in New Jersey, as well as New York City.

Following the interviews, public information sessions were held in several locations, including a well-advertised and well-attended drop-in session in Rutherford, New Jersey held in January 2005. Two public informational meetings/availability sessions were held in September 2005: one in Rutherford, New Jersey, and one in Newark, New Jersey. An information table was staffed by representatives of the Lower Passaic River Restoration Project partner agencies at the Passaic River Regatta held in October 2005 at the Nereid Boat Club in Rutherford, New Jersey. This event brought together various groups and citizens interested in the revitalization and conservation of the Passaic River.

Representatives from the partner agencies have participated in Passaic River Symposia held at Montclair State University in Montclair, New Jersey in 2004 and 2006, presenting up-to-date work being conducted on the project.

Community involvement efforts have also included municipal outreach. In April 2007, a municipalities workshop for the Lower Passaic River Restoration Project and the Newark Bay Study Area RI/FS was held at the New Jersey Transportation Planning Authority (NJTPA) in Newark, New Jersey. This workshop consisted of an all-day session focusing on project updates, planning, agency coordination, and revitalization of the river (often addressing community-specific concerns). The event attracted approximately 75 attendees, including Alan Steinberg, the USEPA Regional Administrator. Municipalities that participated in the workshop include Bayonne, Bloomfield, Clifton, Elizabeth, Garfield, Harrison, Newark, Nutley, and Rutherford.

A municipalities meeting was held in July 2007 at the NJTPA to discuss cleanup options for the Lower Passaic River. Objectives for the meeting included briefing the municipalities on the Source Control Early Action FFS, obtaining input from the municipalities on the FFS, and continuing discussions on how the municipalities plan to use the river once it has been revitalized. Municipalities that participated in the meeting include Kearny, Harrison, Hudson County, and Newark.

Municipalities had a direct influence on the development of the remedial alternatives for the FFS. Specifically, the NJDOT prepared a memorandum presenting the State's recommendations for future navigational use of the channel (Appendix F of the FFS; Malcolm Pirnie, Inc., 2007b), which was based on surveys of municipality planning officials and developed in consideration of municipal master plans.

Throughout these community involvement efforts, partnering with local environmental and civic organizations has been an essential component in informing community members about project meetings and other events. These organizations have posted meeting announcements, press releases, and project information on their websites, which facilitates further outreach to local communities than the partner agencies could have done alone. In addition, partnerships with local organizations foster good faith among community members. Local organizations that have participated include the Association of New Jersey Environmental Commissioners, Bloomfield Third Riverbank Association, Clean Ocean Action, Future City, Green Faith, Hackensack Riverkeeper, Immigration and American Citizenship Organization, Ironbound Community Corporation, Jersey Coast Anglers, Nereid Boat Club, New York/New Jersey Baykeeper, and Passaic River Rowing Association.

The public website for the Lower Passaic River Restoration Project, www.ourPassaic.org, serves as another resource for interested parties to obtain background information, meeting notices, and other project-specific information. The website is maintained by the USEPA and is updated continually as new information becomes available. In addition, the website offers the opportunity for local organizations and individuals to sign up for a ListServ, which delivers project announcements directly to its subscribers via e-mail.

Stakeholder workgroup sessions have been held by USEPA over the past three years and have included presentations and dialog on specific topics, such as modeling; sampling plans, activities, and results; and remedial options development and evaluation. In addition, stakeholder representatives have been welcomed at periodic Project Delivery Team meetings where updates of project progress were provided by the partner agencies and stakeholder input was sought. Advance announcements of these meetings were provided directly to stakeholder representatives and via the public website.

A Technical Assistance Grant was awarded to the Passaic River Coalition in 2004. It is being used by the Passaic River Coalition's technical advisor to review information, produce newsletters, and post reports on the Internet about the Passaic River and Newark Bay studies, including information about the Source Control Early Action.

3.3 COORDINATE WITH STATES, LOCAL GOVERNMENTS, TRIBES, AND NATURAL RESOURCE TRUSTEES

The Lower Passaic River Restoration Project is an integrated Study being implemented by the USEPA and several partner agencies as a joint CERCLA-WRDA project. The USACE – New York District serves as the federal WRDA sponsor of the Study, the NJDOT is the non-federal WRDA sponsor, and the NJDEP, NOAA, and USFWS are the Natural Resource Trustees for the Study. Each of these agencies has been involved in the various components of the Study, including the development of planning documents, review of planning and technical documents prior to public release, identification of ARARs, and other aspects of the Study. Each agency attends FFS-specific remedial options workgroup meetings, including comment resolution and consensus meetings. In addition, each agency has had the opportunity to contribute to USEPA decision-making as integral team members throughout the Study.

3.4 DEVELOP AND REFINE A CONCEPTUAL SITE MODEL THAT CONSIDERS SEDIMENT STABILITY

A Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c) and a CSM (Malcolm Pirnie, Inc., 2007a) have been developed for the Study, and sediment stability was considered in the development of both of these documents. The HHRA and ERA (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b), the Pathways Analysis Report (Battelle, 2005), and a Baseline Ecological Risk Assessment workshop held in 2006 [in preparation for the development of the Draft Field Sampling Plan Volume 2 (Malcolm Pirnie, Inc., 2006b)] also contributed to sediment stability discussions presented in the CSM. The initial CSM (Malcolm Pirnie, Inc., 2005a) was based on geochemical and modeling work dating back to 2003 and has been revised (Malcolm Pirnie, Inc., 2007a) using available data and incorporating new data as they were developed. Sediment stability has been investigated in several components of the Study, including the bathymetric analysis and dated sediment core analysis (both discussed in Malcolm Pirnie, Inc., 2006c and Malcolm Pirnie, Inc., 2007a), Sedflume analysis (presented in Borrowman *et al*., 2006), and sediment transport and modeling efforts (Appendix G of the FFS; Malcolm Pirnie, Inc., 2007b).

The Sedflume analysis consisted of erodibility experiments performed on 28 sediment cores from the Lower Passaic River in May-June 2005. The purpose of the Sedflume analysis was to measure the variability of erosion rates with depth of relatively undisturbed sediment core samples extracted from the site. The analysis indicated that sediment cores from some locations within the Lower Passaic River showed resistance to erosion (with approximately 30 to 40 percent fines and measured erosion rates of less than 1×10^{-2} centimeters per second for a 3.2 Pascal shear stress), while cores from other locations within the river were very susceptible to erosion at low shear stress. Noteworthy heterogeneity was observed between replicate cores from the same sampling location.

It is important to note that the consideration of sediment stability (or lack thereof in several locations through the Lower Passaic River) played a major role in prompting the development of the FFS (Malcolm Pirnie, Inc., 2007b) for legacy sediments in the lower 8 miles of the river, which were identified as a major source of contamination to the 17-mile Study Area and to Newark Bay. The FFS was undertaken to evaluate a range of remedial alternatives that might be implemented as an early action to control that major source and more rapidly reduce risks to human health and the environment.

In addition to the work described above, a screening analysis to identify target areas based on sediment stability has been performed. The analysis identified the most erosive reach of the river and subsequently found that remediation of that reach alone was insufficient to achieve the required risk reduction. The FFS also incorporated modeling of the stability of cap materials placed in the erosive setting of the Lower Passaic River (Appendix G of the FFS; Malcolm Pirnie, Inc., 2007b).

Additional Discussion on Sediment Stability Analysis

To be addressed.

3.5 USE AN ITERATIVE APPROACH IN A RISK-BASED FRAMEWORK

An iterative approach has been used throughout the Study with respect to the assessment of available data and the development of new data. Each effort builds on previous efforts, and each component of the Study aims to derive as much information out of new and existing data as possible. Geochemical efforts include the Technical Memorandum: Preliminary Geochemical Evaluation (Malcolm Pirnie, Inc., 2005b), which was further developed into the Draft Geochemical Evaluation (Step 2) (Malcolm Pirnie, Inc., 2006c). Other components of the Study, including the Pathways Analysis Report (Battelle, 2005), the ecological workshop (2006), and the Risk Assessment performed for the FFS (Appendix C of the FFS; Malcolm Pirnie, Inc., 2007b) have also built upon each other, further refining the characterization of ecological risks and exposure pathways with each new effort. The 17-mile study will incorporate a more detailed risk assessment, which will build upon the conservative estimates for current and future risk levels generated in the streamlined FFS Risk Assessment.

Sampling efforts have also employed an iterative approach. Bathymetric surveys performed in the fall of 2004 (as well as previous field investigation studies) aided in the development of the intensive geophysical and geotechnical sampling programs in the spring of 2005. Sediment coring and water column investigations conducted from summer 2005 through early 2006 then built upon the geophysical and geotechnical studies, as well as on earlier coring studies conducted by TSI, partner agencies, and others. A kingfisher study performed by USACE – New York District and NJDOT and a sampling plan for biological characterization efforts (both discussed in Malcolm Pirnie, Inc., 2006b; anticipated to be implemented by the CPG) likewise builds upon previous biological sampling programs conducted by Tierra Solutions, Inc., as well as an Environmental Resource Inventory and Ecological Functional Analysis performed by Earth Tech, Inc. (Malcolm Pirnie, Inc., 2006b). Field investigations in 2004 also provided data for the development of the Environmental Dredging Pilot Study and ex-situ sediment stabilization demonstration in late 2005 (Malcolm Pirnie, Inc., 2006d). The Environmental Dredging Pilot Study evaluated dredge performance, productivity, and sediment resuspension associated with an Environmental Dredging Demonstration and assessed the treatability and beneficial use of contaminated sediment through a Sediment Decontamination Technology Demonstration.

In addition to the iterative approach used in field investigation programs and data analysis efforts, the Source Control Early Action FFS builds upon available data to address the ongoing release of legacy sediments through erosion and resuspension, while the full RI/FS for the 17-mile Study Area is ongoing. The development of the FFS represents an iterative approach to the development of remedial options for the Lower Passaic River.

3.6 CAREFULLY EVALUATE THE ASSUMPTIONS AND UNCERTAINTIES ASSOCIATED WITH SITE CHARACTERIZATION DATA AND SITE MODELS

Key documents leading to the development of the FFS (Malcolm Pirnie, Inc., 2007b) included detailed evaluations of assumptions and uncertainties. These evaluations were performed in the CSM (Malcolm Pirnie, Inc., 2007a) and the EMBM (Appendix D of the FFS; Malcolm Pirnie, Inc. 2007b), including an identification of data gaps. The conclusions presented in these documents are framed around key inferences and uncertainties. In addition, the Cap Erosion and Flood Modeling (Appendix G of the FFS; Malcolm Pirnie, Inc., 2007b) includes a detailed discussion of important assumptions and uncertainties in the modeling process.

Uncertainties in the CSM, EMBM, Cap Erosion and Flood Modeling, and Risk Assessment are summarized below.

- <u>CSM</u>: Uncertainties in the CSM are based on data gaps in the data sets used to develop the document. For example, very limited field data exist for areas upriver of RM7 and between RM0 and RM1. Water column and hydrodynamic data are also incomplete for the Lower Passaic River. [Refer to the CSM (Malcolm Pirnie, Inc., 2007a) for a detailed list of data gaps associated with the sediment beds and water column.] Other uncertainties involve the appropriate linkage of the human health and ecological exposure pathways and receptors (Battelle, 2005) to construct the CSM.

- EMBM: The uncertainty and variability in the measured concentrations used in the EMBM (both source profiles and receptor concentrations) were evaluated using a one-dimension Monte Carlo approach, which examined the range of solids contributions presented in Figure 2.4-8. In this approach, a distribution was specified for each concentration based on the observed values, and the mass balance calculations were repeated 5000 times using randomly selected concentrations for the sources and receptor. In general, the Monte Carlo analysis results indicated that resuspension of legacy sediments varies from 5 to 15 percent of the total solids contribution, the solids contribution from the Upper Passaic River is similar to that from Newark Bay (each contributing approximately 40 percent), and the solids contribution from major tributaries is similar to that from CSO/SWOs (each contributing approximately 5 percent). Refer to Section 2.4.6.1 "Empirical Mass Balance Model" for additional discussion on uncertainty in the EMBM.

- Cap Erosion and Flood Modeling: An uncertainty associated with the Cap Erosion Modeling is that the analysis does not include the consideration of any sands (non-cohesive) and cohesive soils that might enter the Lower Passaic River at the Dundee Dam or from rainfall-related runoff from the drainage area below the Dundee Dam. Hence, the Cap Erosion Modeling results (Appendix G of the FFS; Malcolm Pirnie, Inc., 2007b) may be considered to be conservative in nature. A sensitivity analysis was performed as part of the Flood Modeling (Appendix G of the FFS; Malcolm Pirnie, Inc., 2007b) to account for shoreline and land elevation uncertainties of +/- 1 foot. The results suggest that the flooding area during the 100- and 500-year floods would increase by as much as 62 and 32 percent, respectively, when the land elevation input into the model was reduced by 1 foot (compared to the original land elevation used in the analysis).

- Risk Assessment: Summaries of the major uncertainties in the HHRA and ERA are presented in Table 2.6-5 and Table 2.6-12, respectively.

Although the various data analysis and modeling efforts associated with the Lower Passaic River Restoration Project require that inferences be made and uncertainties be considered, these inferences have been derived from a thorough and comprehensive understanding of the site through the CSM, which was built upon detailed geochemical data evaluations and the assimilation of various data sources. Inferences have been conservative whenever possible and are rationally derived from the CSM. Inferences have been coherent and consistent and, particularly in the EMBM, they work together to provide a more complete understanding of site processes and characteristics.

3.7 SELECT SITE-SPECIFIC, PROJECT-SPECIFIC, AND SEDIMENT-SPECIFIC RISK MANAGEMENT APPROACHES THAT WILL ACHIEVE RISK-BASED GOALS

The selection of site-specific, project-specific, and sediment-specific risk management approaches is reflected in the development of the active remedial alternatives presented in the FFS (Malcolm Pirnie, Inc., 2007b). The alternatives were developed without a presumption of a specific remedy. Based on the Risk Assessment performed for the FFS, three basic approaches were considered: natural recovery processes; remedial action in a small area of the Lower Passaic River; and remedial action in the entire eight-mile stretch of the Area of Focus. It was necessary to address the entire eight-mile stretch in order to achieve the required risk reduction within a reasonably foreseeable time frame. The active remedial alternatives presented in the FFS were developed to address contamination in this eight-mile stretch.

The elements used to construct the remedy were developed in consideration of site-specific, project-specific, and sediment-specific aspects. To determine whether the placement of an engineered sand cap with armor would result in additional flooding impact to the area surrounding the Lower Passaic River, a site-specific analysis was conducted to evaluate the response of the water surface elevation in the Lower Passaic River to the modified bathymetry and roughness associated with alternatives involving containment (to reflect the placement of an engineered cap) and to the hydrodynamic conditions present during an extreme event. [This analysis is described in Appendix G of the FFS (Malcolm Pirnie, Inc., 2007b).] Furthermore, the configuration of the navigation channel, and the requisite amount of sediment removal to both construct the channel and subsequently cap the area to aid in achievement of risk reduction objectives, was developed in consideration of the site-specific navigation needs of the municipalities lining the banks of the Lower Passaic. The understanding of the interplay between deposition and discharges, which led to thick sequences of contaminated fine-grained sediment built up over native, less-contaminated sands, was used to select sediment-specific approaches for covering the dredged surface (*i.e.*, engineered capping was selected to cover areas in which fine-grained sediment remained after dredging, while sand backfill was chosen for areas in which all fine-grained sediment was removed and a sand surface remained). Finally, the input of a diverse ground of project-specific stakeholders was utilized at various points in the development of the remedy.

The background levels for many of the contaminants in the Lower Passaic River pose unacceptable risks, in part resulting from continuing contributions from upstream sources. Thus, while the Source Control Early Action addresses the contaminated sediments of the lower eight miles of the Passaic River, a separate source control action is necessary above Dundee Dam to identify and reduce or eliminate those background sources. Such a separate action might include identifying facilities above the dam with on-going contributions to the Upper Passaic River, or conducting a track-down program where samplers are placed further and further upstream until contaminants are tracked back to specific industrial or municipal sources. Such sources would then be controlled through federal or State of New Jersey regulatory programs.

Because of the contaminant load from the Upper Passaic River, any remedial effort within the Lower Passaic River can only be expected to meet the risk-based PRGs once the load from above the Dundee Dam also meets the PRGs. The load from the Upper Passaic River can be considered a baseline that represents the maximum concentration that would be expected in the Lower Passaic River (dilution from other less contaminated sediment sources would cause the concentrations in the Lower Passaic River to be less than what is contributed over the Dundee Dam).

During the implementation of the Source Control Early Action, it is possible that newly-capped areas may be re-contaminated with contaminated sediment from the Upper Passaic River and with resuspended solids from yet-to-be capped areas due to the effects of tidal mixing in the Lower Passaic River. This re-contamination can be minimized through the use of engineering controls during construction; the cap can be placed in increments over large areas so that it is gradually less contaminated as the cap is constructed. In addition, re-contamination of newly-capped areas with Upper Passaic River sediments may be mitigated through a separate source control action above Dundee Dam. The USEPA plans to initiate work to identify and characterize contamination entering the Lower Passaic River from the Upper Passaic River (Malcolm Pirnie, Inc., 2007b).

3.8 ENSURE THAT SEDIMENT CLEANUP LEVELS ARE CLEARLY TIED TO RISK MANAGEMENT GOALS

PRGs provide long-term targets to use during analysis and selection of remedial alternatives. Ideally, such goals, if achieved, should both comply with ARARs and result in residual risks that satisfy the NCP requirements for the protection of human health and the environment. The PRGs were calculated considering the consumption rates for the adult consumer of fish based on the exposure assumptions used in the HHRA. Based on the comparability of the consumption rates for consumption of fish and crab, additional

PRGs for consumption of crab were not included in the assessment (*i.e.*, 25 grams per day compared to 23 grams per day).

Another consideration in the development of the long-term targets is the background contamination and its contribution to residual risks. The background contaminant contributions to the Study Area were also considered during PRG development to adequately understand contaminant sources and establish realistic risk reduction goals. Investigation of contaminants in the sediment of the Upper Passaic River above the Dundee Dam revealed historic and ongoing upstream sources of metals, pesticides, and PCBs. The upstream concentrations of these contaminants are significant in comparison to their concentrations in the Lower Passaic River. USEPA guidance defines "background" as levels of chemicals that are not influenced by releases from the site, including both anthropogenic and naturally derived constituents. The dam physically isolates the proximal Dundee Lake and other Upper Passaic River sediments from Lower Passaic River influences while the Lower Passaic River receives contaminant loads from above the dam. The proximity of these sediments to the proposed remediation area and demonstrated geochemical connection to a portion of the Lower Passaic River sediment contamination strongly argues in favor of considering the Upper Passaic River to be background for the Lower Passaic River.

For human health, the sediment background concentration for PCBs is the only concentration associated with cancer risks and non-cancer health hazards that exceed the NCP criteria. Estimates of the cancer risk and non-cancer health hazard associated with the PCB background sediment concentration for an adult angler consuming fish or crab from the Lower Passaic River are estimated to be $4x10^{-4}$ and 26, respectively. The selection of the background concentration emphasizes the need to investigate and remediate the area above the Dundee Dam to reduce this ongoing contribution to risks in the Lower Passaic River following remediation.

Risks associated with background concentrations for ecological receptors were also estimated. The HIs for both benthic macroinvertebrates (based on sediment benchmarks and CBRs) and fish (CBRs) range from 360 to 7,900, while those for the wildlife receptors (*e.g.*, mink and heron) are considerably lower, ranging from 3.6 to 8.8. Background levels of pesticides contribute most substantially to the benthic macroinvertebrate HIs, while copper dominates the HIs for both fish receptor categories, with Total DDT also important in the case of the AE/WP category (39 percent). In the case of the mink receptor, the overall risks associated with background conditions are dominated by contributions from Total PCBs and TCDD TEQ (based on 2,3,7,8-TCDD). Finally, the primary contributors to the HI for the heron (under both diet scenarios) are mercury, Total PCBs, and Total DDT.

The background levels for many of the contaminants pose unacceptable risks, in part resulting from continuing contributions from upstream sources. Thus, while the Source Control Early Action addresses the contaminated sediments of the lower eight miles of the Passaic River, a separate source control action is necessary above Dundee Dam to identify and reduce or eliminate those background sources. Such a separate action might include identifying facilities above the dam with on-going contributions to the Upper Passaic River, or conducting a track-down program where samplers are placed further and further upstream until contaminants are tracked back to specific industrial or municipal sources. Such sources would then be controlled through federal or State of New Jersey regulatory programs. The USEPA plans to initiate work to identify and characterize contamination entering the Lower Passaic River from the Upper Passaic River (Malcolm Pirnie, Inc., 2007b).

The use of background concentrations rather than purely risk-based goals considers the degree of recontamination expected over time after the Source Control Early Action has been implemented. The use of background concentrations also affects the amount of time required for MNR to succeed after implementation of the Source Control Early Action, rather than the areal coverage of capping and depth of dredging required for the remedial action itself. However, it important to note that preliminary remediation goals would be achieved in a shorter time frame if the fine-grained sediments in the 11 miles of the Lower Passaic River above the Area of Focus were targeted as part of the Source Control Early Action.

3.9 MAXIMIZE THE EFFECTIVENESS OF INSTITUTIONAL CONTROLS AND RECOGNIZE THEIR LIMITATIONS

Institutional controls to be implemented after the Source Control Early Action focus on use restrictions on the waterway. Existing fish consumption advisories will remain in effect and will be gradually relaxed according to risk thresholds as sediment and fish tissue concentrations improve over the long-term. (See Section 2.7.2 "Preliminary Remediation Goals" for PRGs for contaminants that tend to bioaccumulate in fish, such as dioxin, PCBs, and mercury.) Fish consumption advisories have definite limitations, however. Although fish consumption advisories are currently in place for the Lower Passaic River, creel surveys of anglers along the river have found that a considerable proportion of the group continues to consume fish and crab above the "eat none" advisory; this consumption poses a risk to these residents. As an institutional control, coordination between the NJDEP and USEPA regarding the issuance of fish consumption advisories will be necessary. Also, it may be necessary to implement outreach programs to inform the community regarding the advisories.

In addition to fish consumption advisories, waterway use restrictions will include restrictions on dredging to create additional berths after the implementation of the Source Control Early Action. After implementation of the remedy, there will likely be stringent restrictions on dredging portions of the river that have been capped because of the potential for enhanced recontamination of the capped surface over a large area due to resuspension of contaminated sediments from below the cap and subsequent tidal mixing. Therefore, if a proposed berth area is identified in a capped area, the dredging to create this berth area would need to be conducted such that resuspension of contaminated sediments in the berth area is minimized or avoided. (This may be accomplished by completely surrounding the area to be dredged with sheet pile; however, the installation of sheet pile may create secondary effects such as the restriction of river flow and associated impacts to river flooding, as well as increased cap scour adjacent to the area to be dredged. An evaluation of these secondary effects would be required prior to dredging.) In addition, replacement of the engineered cap in the new berth area would be required.

Like other institutional controls, placing restrictions on dredging portions of the river that have been capped has its limitations. Controls on post-remediation dredging to minimize resuspension of contaminated sediments still incorporate some risk of recontamination of adjacent areas.

3.10 DESIGN REMEDIES TO MINIMIZE SHORT-TERM RISKS WHILE ACHIEVING LONG-TERM PROTECTION

As part of the FFS, the short-term risks associated with each of the active remedial alternatives were evaluated and compared. (See Section 2.9.5 "Short-Term Effectiveness" for a summary of these evaluations.) predecisional -deliberative

predecisional -deliberative

however, there are tradeoffs when considering short-term and long-term impacts. For example, the option to dredge contaminated sediments was not rejected simply because dredging will cause some resuspension of particle-bound contamination. Since sediment resuspension is currently ongoing, and the ultimate goal of the Source Control Early Action is to drastically reduce erosion and resuspension of legacy sediments as a source of contamination to the river, the additional short term potential resuspension associated with dredging operations was not a deciding factor when evaluating the long term protection achieved by active remedial alternatives involving dredging.

All aspects of remedy design and implementation will be developed in consideration of Health and Safety Plans generated to provide protection and reduce risks for workers and the surrounding community. Community outreach programs would be performed to understand the communities' health concerns during the project, and coordination with community members would be undertaken to identify actions needed to protect their health and safety. Work areas in the river would be isolated (access-restricted) for safety reasons. In addition, selected aspects of the remedy design which may be incorporated to reduce short-term risks include:

- Construction and Operation of a Support Area: The site for the support area is assumed to have riverfront access, and access to these areas would be restricted to authorized personnel. An ambient air monitoring program could be implemented where required to provide protection for the surrounding community. As the land use near the Lower Passaic River is primarily industrial, minimal additional environmental impact is likely to arise from the construction of the support area.

- Dredging: Dredging operations (including dredging and transportation of dredged material) will inevitably involve short-term impacts associated with resuspension of sediment. However, installation of structures to isolate areas of dredging would also likely result in some degree of resuspension, and would result in a longer timeframe necessary to achieve remedial action objectives. For these reasons, the utilization of best management practices and specialized technology is more likely to achieve a more favorable balance between short-term impact and long-term risk reduction than dredging using containment structures.

- Capping: Capping operations may be less disruptive of local communities than dredging (USEPA, 2005c), and would result in less potential for noise disturbances and air pollution than dredging operations. Environmental impacts during capping would be mitigated by using cap placement techniques that avoid resuspension to the extent practicable, but a temporary loss of habitat would be an inevitable impact associated with the placement of cap material.

- CDF Construction and Operation: Activities associated with capping and CDF construction would also result in a temporary loss of habitat for aquatic and benthic organisms. However, the use of a CDF for dredged material storage and disposal would likely result in a shorter timeframe for achievement of RAOs, as the potential for delay and issues with throughput and capacity associated with other transport and disposal methods would be eliminated.

- Thermal Treatment: Thermal destruction was included in the remedy development because it is one of the only technologies proven as effective in treating the organic COPCs and COPECs (*i.e.*, PCDD/F, PCB, and PAH) detected in the sediment of the Area of Focus. Air emissions generated by a thermal destruction facility would be strictly monitored and controlled to ensure protection of the surrounding community and air quality.

3.11 MONITOR DURING AND AFTER SEDIMENT REMEDIATION TO ASSESS AND DOCUMENT REMEDY EFFECTIVENESS

Monitoring is incorporated into the Source Control Early Action and includes monitoring during implementation of the remedy and after implementation has been completed. Both the effort and the estimated costs for monitoring have been evaluated for the remedy and are presented in the FFS (Malcolm Pirnie, Inc., 2007b). Monitoring includes chemical analyses to characterize sediments and the water column, as well as biological tissue. Table 3.11-1 summarizes the annual monitoring activities that are incorporated into the Source Control Early Action. In addition to these activities, the Source Control Early Action includes five-year remedy reviews as required under CERCLA Section 121(c).

Table 3.11-1: Source Control Early Action Annual Monitoring Program

Monitoring Type	Monitoring Frequency	Monitoring Parameters
Surface Sediment Sampling	400 samples per year; 5 samples taken at transects of 0.1 river mile	• Geotechnical parameters (grain size, percent moisture, TOC) • Target Analyte List metals • Cyanide • Dioxins
Water Column Sampling	35 samples per year; 2 samples taken for 2 tidal cycles per river mile	• Total suspended solids • TOC
Groundwater Sampling	144 samples per year; 12 wells sampled per month	• Parameters to be determined
Biological Monitoring	One monitoring program per year	• Habitat delineation • Terrestrial vegetation • Avian community • Aquatic community • Aquatic vegetation (SAV) • Fish community • Benthic invertebrates • Biological tissue-residual • Toxicity testing

In addition to the monitoring activities discussed above, remedy effectiveness would also be maintained through cap maintenance efforts, which could be required in perpetuity.

4.0 ACRONYMS

2,3,7,8-TCDD	2,3,7,8-Tetrachlorodibenzodioxin
AE/WP	American eel and white perch
AOC	Administrative Order of Consent
ARAR	Applicable or Relevant and Appropriate Requirement
AT	Averaging Time
ATSDR	Agency for Toxic Substance and Disease Registry
BAF	Bioaccumulation Factor
BDA	Brownfield Development Area
Be-7	Beryllium-7
CAD	Confined Aquatic Disposal
CBR	Critical Body Residue
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CMB	Chemical Mass Balance
COPC	Contaminant of Potential Concern
COPEC	Contaminant of Potential Ecological Concern
CPG	Cooperating Party Group
Cs-137	Cesium-137
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
CSTAG	Contaminated Sediment Technical Advisory Group
CTE	Central Tendency Exposure
CWA	Clean Water Act
cy	cubic yard

DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
Total DDT	Sum of DDD, DDE, and DDT isomers
DMM	Dredged Material Management
EFH	Exposure Factors Handbook
EMBM	Empirical Mass Balance Model
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ER-L	Effects Range-Low
FC	Future Conditions Assumption
FFS	Focused Feasibility Study
f/k/a	formerly known as
HHRA	Human Health Risk Assessment
HI	Hazard Index
HMW	High Molecular Weight
HQ	Hazard Quotient
HRC	High Resolution Core
H:V	Horizontal:Vertical
IRIS	Integrated Risk Information System
LMW	Low Molecular Weight
LOAEL	Lowest Observed Adverse Effect Level
LWA	Length-Weighted Average
M	Modeling Assumption
mg/kg	milligram per kilogram
mg/kg-day	milligram per kilogram per day
mg/L	milligram per liter
MLW	Mean Low Water
MNR	Monitored Natural Recovery

NA	Not Available
NCP	National Contingency Plan
ND	Not Determined
ng/g	nanogram per gram
ng/kg	nanogram per kilogram
NHPA	National Historic Preservation Act
N.J.A.C.	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJPDES	New Jersey Pollutant Discharge Elimination System
N.J.S.A.	New Jersey Statues Annotated
NJTPA	New Jersey Transportation Planning Authority
NOAA	National Oceanic and Atmospheric Administration
NOAEL	No Observed Adverse Effect Level
NPL	National Priority List
NRRB	National Remedy Review Board
O&M	Operations & Maintenance
OCC	Occidental Chemical Corporation
OSWER	Office of Solid Waste and Emergency Response
OU	Operable Unit
PAH	Polycyclic Aromatic Hydrocarbon
PATH	Port Authority Trans Hudson
PCB	Polychlorinated Biphenyl
PCDD/F	Polychlorinated Dibenzodioxins/Furans
POTW	Publicly Owned Treatment Works
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
PRSA	Passaic River Study Area
RAGS	Risk Assessment Guidance for Superfund

RAO	Remedial Action Objective
RBC	Risk-Based Concentration
RCRA	Resource Conservation and Recovery Act
RfD	Oral Reference Dose
RI/FS	Remedial Investigation/Feasibility Study
RM	River Mile
RME	Reasonable Maximum Exposure
ROD	Record of Decision
SP	System Process Assumption
SPMD	Semi-permeable Membrane Device
ST	Source Term Assumption
SWO	Stormwater Outfall
TBC	To Be Considered
TCDD	Tetrachloridibenzodioxin
TCLP	Toxicity Characteristic Leaching Procedure
TEF	Toxic Equivalent Factor
TEQ	Toxic Equivalent Quotient
TOC	Total Organic Carbon
TRV	Toxicity Reference Value
TSCA	Toxic Substances Control Act
TSI	Tierra Solutions, Inc.
TSS	Total Suspended Solids
UCL	Upper Confidence Limit
μg/g	microgram per gram
μg/kg	microgram per kilogram
USACE	United States Army Corps of Engineers
U.S.C.	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service

USGS	United States Geological Survey
WHO	World Health Organization
WRDA	Water Resources Development Act

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